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## TECHNICAL MEMORANDUM

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TITLE: MUFAN, A Computer Program for the Analysis of Multi-Loop Fluid Flow Systems

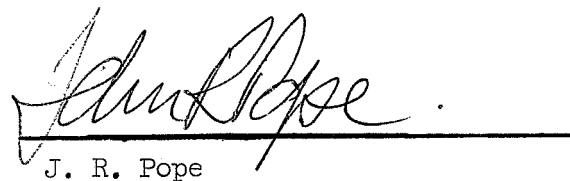
## ABSTRACT

MUFAN may be used to determine flow rates, pressures, and pressure drops in systems involving one-dimensional incompressible steady state fluid flow. The system may consist of one or more branches or loops. The program is coded in FORTRAN IV (G) for the IBM 360/65 computer.

Key Words: MUFAN, Fluid Flow, One-Dimensional, Incompressible, Steady-State, Multi-Loop, Piping System

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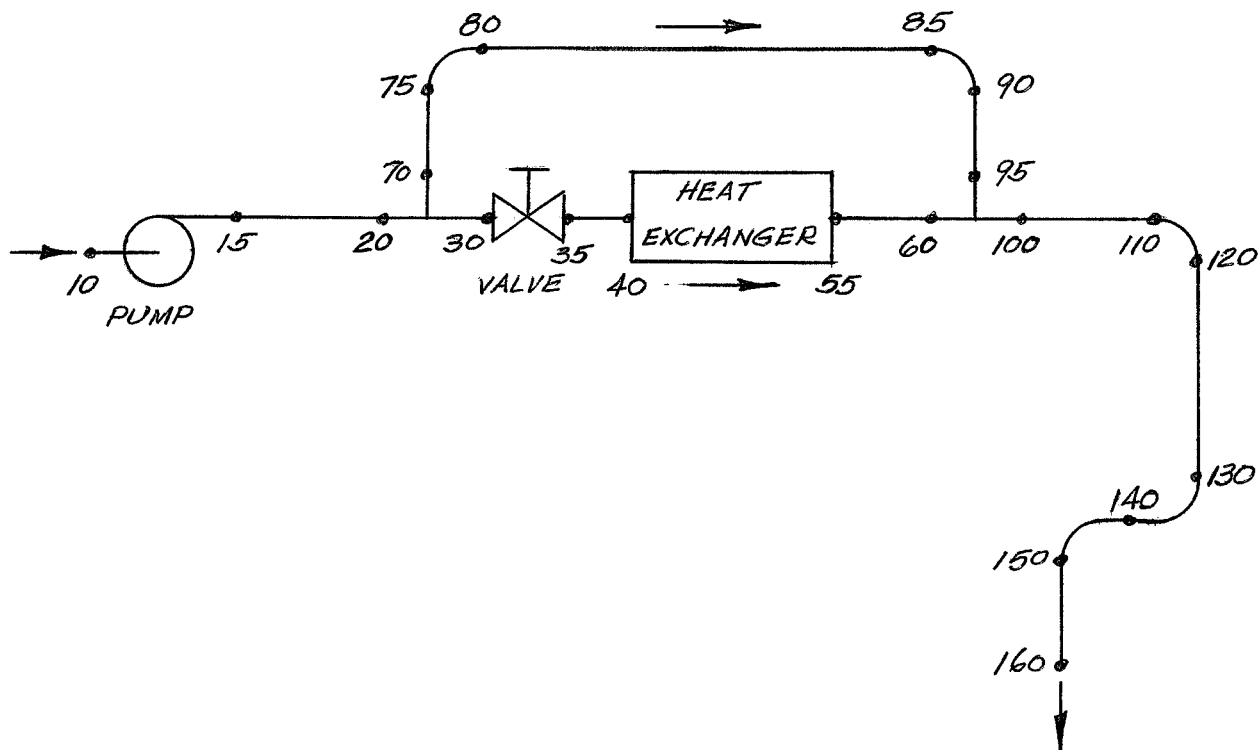
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## 1.0 INTRODUCTION

MUFAN is a computer program (coded in FORTRAN IV (G) for the IBM 360/65) which solves fluid flow systems involving one or more branches or loops for flow rates, pressure drops and pressures. The program is primarily intended for the analysis of piping systems and the flow is assumed to be one-dimensional, incompressible and steady-state. Friction head loss data for several fittings commonly found in piping systems is built into the program as well as density and viscosity data for liquid water, liquid NaK, liquid mercury and 4P3E.

## 2.0 USER'S GUIDE

The first step in preparing data for MUFAN is to make a schematic of the system to be analyzed. The schematic should include only the details necessary for the fluid flow analysis. The next step is to indicate nodes (or stations) on the schematic. There must be a node at both ends of each fitting, pump, component, etc. Each node is then assigned a unique number from 1 to 500 (inclusive). The nodes may be numbered in any manner desired; however, it is suggested that, for the sake of readability, the nodes be numbered in increasing order in the direction of fluid flow and that numbers be left out so that, if necessary, additional nodes can be inserted at a later time without disturbing the numbering scheme. An example of a schematic with node numbers appears below.



The next step is to describe each of the members (straight pipes, fittings, pumps, components, etc.) that make up the system. The number of the node at which fluid enters the member and the number of the node at which fluid leaves the member (in that order) must be specified for each member. These pairs of node numbers determine how the members are connected to form the system and also determine the positive direction for fluid flow in each branch of the system. Member data is coded on MEMBER cards which are described in Section 2.1.6. If the member is a pump or component, flow rates are coded on CQ cards (Sec. 2.1.2) and the corresponding  $\Delta P$ 's are coded on CP cards (Sec. 2.1.2).



To complete the description of the system it is necessary to specify the fluid to be used, the fluid temperature at each node point, the elevation at each node point, and the appropriate pressure and fluid flow constraints. The type of fluid to be used is coded on the BEGIN card (Sec. 2.1.1), the temperatures at the nodes and the elevations at the nodes are specified on the NODE cards (Sec. 2.1.7), pressures which are to be fixed are coded on the PRESSURE cards (Sec. 2.1.8), and flow rates to be fixed are coded on the MEMBER card for the first member in the branch for which the flow rate is to be fixed.

The specification of proper fixed pressures and fixed flow rates is crucial to the analysis of the system. MUFAN will reject any system that is either underdetermined or overdetermined. As an example, consider a system which consists of a single straight pipe:



If the pressure is fixed at node 1 and node 2, the system can be solved. If, however, only the pressure at node 1 is fixed, the system is underdetermined and cannot be solved. If the pressure is fixed at node 1 only and the flow rate in the pipe is fixed, the system can be solved. If, however, the pressure at node 1, the pressure at node 2, and the flow rate are all fixed, the system is overdetermined and cannot be solved.

## 2.1 INPUT DATA DECK

The input data for MUFAN is contained on the following types of cards: BEGIN, CP, CQ, END, FD, FT, FV, LABEL, MEMBERS, NODE, PRESSURE, AND TEMPERATURE. The BEGIN card must be the first card in the data deck and the END card must be the last card in the data deck; the remaining cards may appear in any order in the data deck. The data decks for several cases may be "stacked" so that they will be processed in a single computer run. A sample MUFAN deck set up appears below in Figure 1.

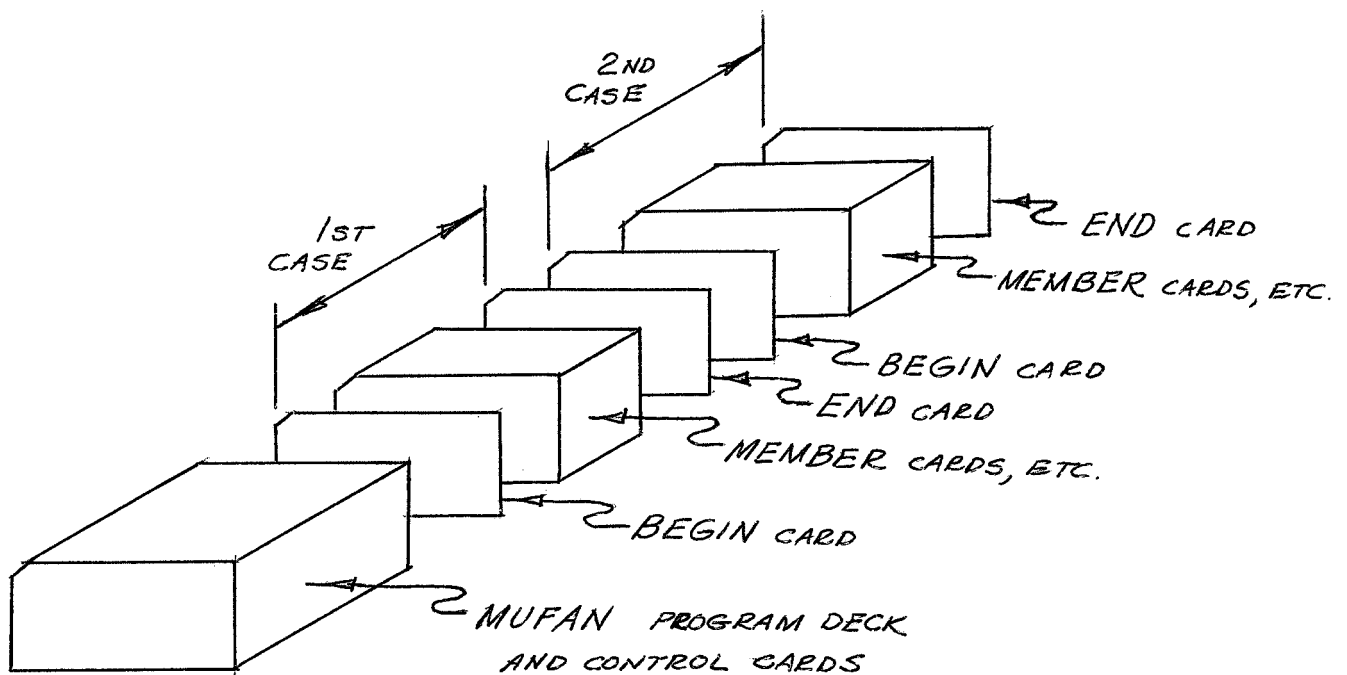


Figure 1 - MUFAN Deck Set-Up

Detailed descriptions of each type of card appear in the sections below.  
The entries under the heading "Field Type" have the following meanings:

A - alphanumeric data (any legal character). If a letter or group of letters appears in capitals under the "Data" heading for that field, the letter or letters must be coded exactly as shown.

F - floating point (real) data. Must have a decimal point. If the E notation is used (for example 2.0E-6 instead of .000002), the exponent must be coded in the right-most column(s) of the field.

I - Integer data. Must be coded in the right-most columns of the field and must not have a decimal point.

X - blank

#### 2.1.1 BEGIN CARD

The BEGIN card must be the first card in the data deck for each case. The format of the card is described below.

CARD COLUMNS	FIELD TYPE	DATA
1	A	B or blank
2-3	X	blank
4	I	Fluid type 1 = NaK 2 = Mercury - liquid 3 = 4P3E 4 = Not used 5 = Water - liquid 6 = Fluid properties input by the user on FD, FT, and FV cards
5-14	F	X - acceleration, g's
15-24	F	Y - acceleration, g's
25-34	F	Z - acceleration, g's
35-44	F	Maximum allowable absolute error in flow rate (- 1.0 lb/hr if left blank)
45-54	F	Maximum allowable relative error in flow rate (=0.01 if left blank)
55-58	I	Maximum number of iterations to be performed (=50 if left blank)
59	X	blank
60	I	=0 or blank - lengths, bend radii and elevations are in feet =1 - lengths, bend radii and elevations are in inches
61-80	X	blank

### 2.1.2 CP and CQ CARDS

CP cards are used to specify pressure drop versus flow rate for components. The component pressure drop (in psi) for selected flow rates is coded on a CP card and the corresponding flow rates (lb/hr) are coded on a CQ card. For pumps, the head in feet of fluid for selected flow rates is coded on a CP card and the corresponding flow rates (in GPM) are coded on a CQ card. MUFAN uses linear interpolation to find values of pressure drop (or fluid head) that correspond to flow rates between the selected values on the CQ card. If a flow rate is less than the smallest flow rate on a CQ card, the pressure drop (fluid head) corresponding to the smallest flow rate on the card is used; if a flow rate is greater than the largest flow rate on a CQ card, the pressure drop (fluid head) corresponding to the largest flow rate is used. The flow rates must be coded in increasing order from left to right on each CQ card.

Component or pump data coded on CP and CQ cards is referenced by assigning a component or pump type number on the CP and CQ cards and also coding that type number on any MEMBER cards that represent a member which is that type of pump or component. For example, suppose that in the system to be analyzed we have several check valves that all have the same pressure drop versus flow rate characteristics. We could code the pressure drop versus flow rate data on a pair of CP and CQ cards, assign a component type, number, say 1, and then code that component type number on each MEMBER card that represents one of the check valves.

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
1-2	A	CP or CQ
3	X	blank
4-7	A	COMP or PUMP
8-10	I	Component type, 1-41, or, pump type, 1-9
11-17	F	1st P, pump head, or flow rate
18-24	F	2nd P, pump head, or flow rate
25-31	F	3rd P, pump head, or flow rate

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
32-38	F	4th P, pump head, or flow rate
39-45	F	5th P, pump head, or flow rate
46-52	F	6th P, pump head, or flow rate
53-59	F	7th P, pump head, or flow rate
60-66	F	8th P, pump head, or flow rate
67-73	F	9th P, pump head, or flow rate
74-80	F	10th P, pump head, or flow rate

#### 2.1.3 END CARD

An END card indicates the end of the data cards for a case and must be the last card in the data deck for each case.

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
1-3	A	END
4-80	X	blank

#### 2.1.4 FD, FT, AND FV CARDS

If the user wishes to use a fluid other than those whose properties are built into the program (NaK, liquid mercury, 4P3E, liquid water), he must supply fluid density and viscosity versus temperature on FD, FV, and FT cards. Selected temperature values (degrees F.) are coded on the FT card, increasing from left to right. The fluid density values (pounds per cubic foot) corresponding to each temperature value are coded on the FD card and the fluid viscosity values (lb./hr.-ft.) corresponding to each temperature are coded on the FV card. Interpolation is performed by Subroutine INT<sup>4</sup> (see Reference 10).

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
1-2	A	FD or FT or FV
3-10	F	1st density, temperature or viscosity value
11-18	F	2nd density, temperature or viscosity value
19-26	F	3rd density, temperature or viscosity value

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
27-34	F	4th density, temperature or viscosity value
35-42	F	5th density, temperature or viscosity value
43-50	F	6th density, temperature or viscosity value
51-58	F	7th density, temperature or viscosity value
59-66	F	8th density, temperature or viscosity value
67-74	F	9th density, temperature or viscosity value
75-80		blank

#### 2.1.5 LABEL CARDS

LABEL cards are used to place title information at the top of each page of MUFAN printout. There may be up to 3 LABEL cards for each case.

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
1	A	L
2-80	A	Any title information desired.

#### 2.1.6 MEMBER CARDS

MEMBER cards are used to describe the members (straight pipe, fittings, components, pumps, etc.) that make up the system that is to be analyzed. Each MEMBER card describes one member.

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
1	A	M
2	X	blank
3-5	I	Number of the node at which fluid enters the member.
6-7	X	blank
8-10	I	Number of the node at which fluid leaves the member.
11-17	X	blank
18-24	F	If member is
		... Straight pipe, gradual expansion or contraction -- code the length in feet or inches
		... A bend -- code the radius in feet or inches
		... None of the above -- leave blank

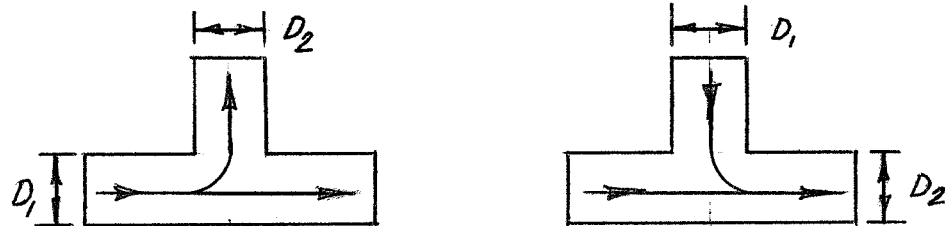
CARD COLUMNS	FIELD TYPE	DATA
25-30	F	Upstream outside diameter, $D_1$ , inches. (See Sect. 2.1.6.1)
31-36	F	Upstream wall thickness, inches
37-41	F	If the member is a bend, code the angle of the bend in degrees (maximum bend angle allowed is $180^\circ$ ). If the member requires a downstream outside diameter ( $D_2$ ), code the downstream wall thickness. If neither of the above apply, leave blank.
42	X	blank
43	I	1 If fixed pressure drop (see Sect. 2.1.6.2) 2 If free pressure drop (see Sect. 2.1.6.2) 3 If fixed pressure rise (see Sect. 2.1.6.2) 0 or blank if none of the above
44	I	1 If fixed flow rate (see Sect. 2.1.6.3) 0 or blank if not
45	I	If the member is a pump, code the type number of the pump, otherwise 0 or blank.
46-47	I	If the member is a component, code the type number of the component, otherwise 0 or blank
48-49	I	If a K-factor is to be used for the member, enter the K-factor code (see Sect. 2.1.6.4), otherwise 0 or blank.
50-51	I	If an equivalent length ( $L_e/D$ ) is to be used for the member, enter the equivalent length code (see Sect. 2.1.6.5), otherwise 0 or blank.
52	X	blank
53-58	F	Depending on what is coded in columns 48-51, enter value of K-factor, value of $L_e/D$ , diameter of orifice ( $D_o$ ), or blank.
59-65	F	Downstream outside diameter, $D_2$ (See Sect. 2.1.6.1)

CARD COLUMNS	FIELD TYPE	DATA
66-72	F	Depending on what is coded in columns 43-44, enter value of fixed flow rate, value of fixed pressure drop, value of fixed pressure rise, or blank.
73-79	F	If the member is a straight pipe or an equivalent length has been selected, enter the roughness in inches, otherwise leave blank
80	X	blank

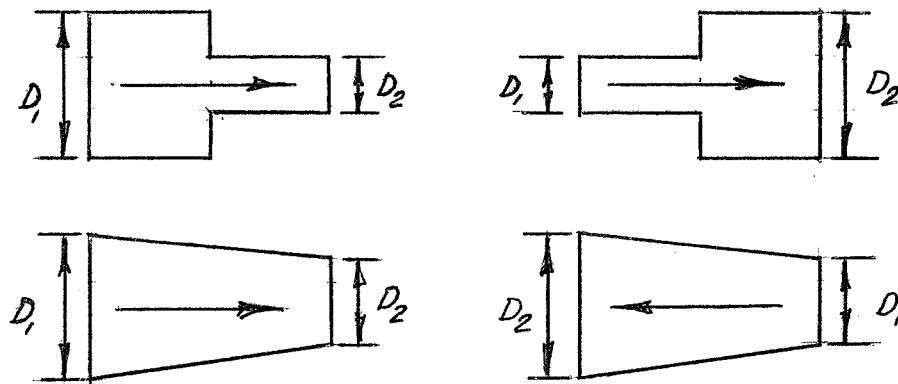
#### 2.1.6.1 OUTSIDE DIAMETER

If a member has a constant diameter from inlet to outlet, the outside diameter,  $D$ ., is coded in columns 25 thru 30 of the member card and the field for  $D_2$  is left blank. If a member has an upstream outside diameter that differs from the downstream outside diameter, the upstream outside diameter ( $D_1$ ) must be coded in columns 25 thru 30 and the downstream outside diameter ( $D_2$ ) must be coded in columns 59-65. Pumps require both  $D_1$  and  $D_2$  whereas  $D_1$  need be coded for components only if a printout of Reynolds number based on  $D_1$  is desired. Examples showing  $D_1$  and  $D_2$  appear below.

*TEE :*



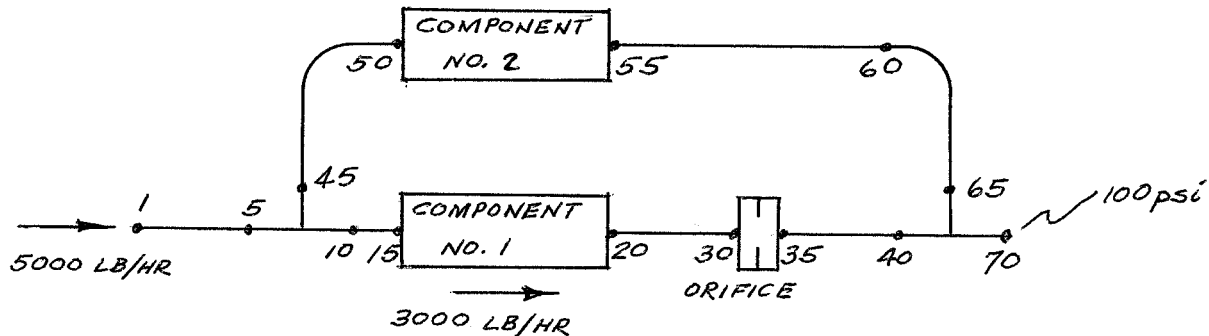
*CHANGES OF SECTION :*





### 2.1.6.2 PRESSURE DROP CONSTRAINTS

If a fixed pressure drop (or rise) is specified for a member, the pressure drop (or rise) provided by the user in columns 66 thru 72 of the MEMBER card is taken to be the pressure drop (or rise) across the member regardless of the flow rate. If a free pressure drop is specified for a member, MUFAN computes the pressure drop required to satisfy the conditions imposed on the system. As an example of the use of a free pressure drop, consider the system shown below:

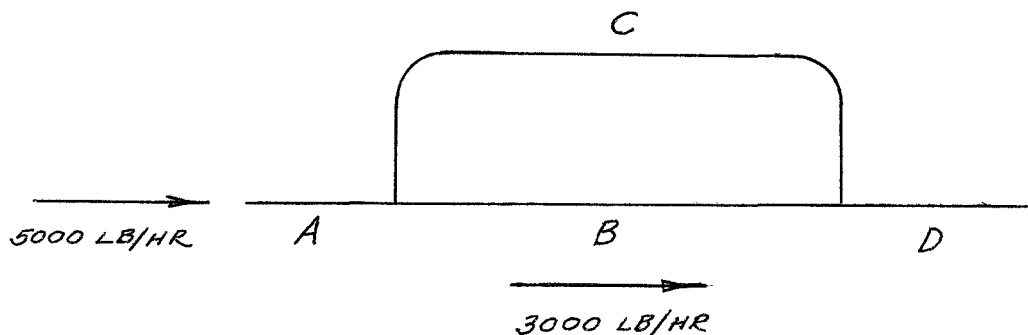


It is desired to size the orifice to obtain the flow distribution shown. To accomplish this, the flow rates shown are coded as fixed and the characteristics of the two components are coded on CP and CQ cards. Member 30-35 is coded as a free pressure drop and the outside diameter is coded in columns 25 thru 30 of the MEMBER card. The remaining members are coded on additional MEMBER cards and the pressure at node 70 is specified on a PRESSURE card. MUFAN will compute the pressure drop from node 30 to node 35 required to obtain that pressure drop. If the outside diameter is left blank on MEMBER card 30-35, the pressure drop will be computed but the orifice diameter will not.

It should be noted that if a fixed pressure drop (or rise) or a free pressure drop is called for, all but the following data items on the MEMBER card are ignored: the node numbers, the outside diameter ( $D_1$ ), the wall thickness, the fixed flow rate flag, and the value of the fixed flow rate (if any).

#### 2.1.6.3 FLOW RATE CONSTRAINTS

If the first member in a branch is coded as having a fixed flow rate, the entire branch is considered to have the same fixed flow rate (to satisfy continuity of mass flow). MUFAN checks to see if the flows fixed by the user imply fixed flows in other branches, and, if so, fixes the flows in these branches. As an example of implicitly fixed flow rates, consider the system shown below:



The flow rates in branches "A" and "B" are fixed at the values shown. To satisfy continuity the flow rate in branch "C" must be 2000 lb/hr. and the flow rate in branch "D" must be 5000 lb/hr., therefore MUFAN would automatically fix the flow rates in these two branches.

#### 2.1.6.4 K-FACTORS

K-factors are used to compute the head loss through bends, fittings, components, etc. according to the relationship:

$$\Delta h = \frac{KV^2}{2g}$$

Where:

h = head loss, ft.

K = K-factor, dimensionless

V = fluid velocity, ft./sec.

g = acceleration of gravity, ft./sec./sec.

If the user chooses to have the program use a K-factor in the head loss computation for a member, he should code one of the numbers listed below, otherwise the field (cols. 48-49) should contain zero or blank. In the descriptions below, "tubing" refers to roughness on the order of smooth tubing while "piping" refers to roughness on the order of cast pipe. See Section 3.1.1 for the K-factor values which are built into the program.

CODE	DESCRIPTION
1	30° or 45° tubing branch-flow out through branch
2	60° tubing branch-flow out through branch
3	90° tubing branch-flow out through branch
4	45° branch on a 90° elbow-flow out through branch
5	7° branch on a 90° elbow-flow out through branch
6	15° branch on a 155° elbow-flow out through branch
7	135° tubing branch-flow out through branch
8	45° tubing branch-flow through main
9	90° tubing branch-flow through main
10	135° tubing branch-flow through main
11	45° tubing branch-flow in through branch
12	90° tubing branch-flow in through branch
13	135° tubing branch-flow in through branch
14	Tubing bend (code the angle of the bend in columns 37-41)
15	Standard 90° pipe elbow
16	Standard 45° pipe elbow
17	Long 90° pipe elbow
18	Standard pipe tee - flow through main
19	Standard pipe tee - flow through branch
20	Close return bend
21	Gradual contraction
22	Gradual expansion
23	Sudden contraction

<u>CODE</u>	<u>DESCRIPTION</u>
24	Sudden expansion
25	Orifice
99	K-factor provided by the user (K-factor value coded in columns 53-58)

#### 2.1.6.5 EQUIVALENT LENGTHS

Equivalent lengths are used to compute the head loss through bends, fittings, components, etc. according to the relationship:

$$\Delta h = f (Le/D) \frac{V^2}{2g}$$

Where:

$\Delta h$  = head loss, ft.

$f$  = friction factor

$Le/D$  = equivalent length, diameters

$V$  = fluid velocity, ft./sec.

$g$  = gravitational acceleration ft./sec./sec.

If the user chooses to have the program use an equivalent length in the head loss computation for a member, he should code one of the numbers listed below, otherwise the field (columns 50-51) should contain zero or blank. In the descriptions below "tubing" refers to roughness on the order of smooth tubing while "pipe" refers to roughness on the order of cast pipe. See Section 3.1.2 for the equivalent length values which are built into the program.

<u>CODE</u>	<u>DESCRIPTION</u>
1	Straight pipe, code the length (feet or inches) in columns 18-24 and code the roughness (inches) in columns 73-79
2	Tubing bend (code the angle of the bend in columns 37-41)
3	Standard 90° pipe elbow
4	Standard 45° pipe elbow
5	Long 90° pipe elbow
6	Close return bend
7	Gate Valve
8	Swing check
9	Angle Valve
10	Globe valve

<u>CODE</u>	<u>DESCRIPTION</u>
11	Standard pipe tee - flow thru main
12	Standard pipe tee - flow thru branch
99	Equivalent length ( $Le/D$ ) provided by the user in columns 53-58.

#### 2.1.7 NODE CARDS

NODE cards are used to input elevation and temperature data for the nodes in the system. Temperature data may be coded on TEMPERATURE cards instead of on the NODE cards if desired. If a node does not have elevation data coded for it on a NODE card, the elevation at that node is considered to be  $X = 0$ ,  $I = 0$ ,  $Z = 0$ . Thus for nodes that have elevation  $X = 0$ ,  $Y = 0$ ,  $Z = 0$  the NODE card may be omitted provided that the fluid temperature for that node is coded on a TEMPERATURE card.

<u>CARD COLUMNS</u>	<u>FIELD TYPE</u>	<u>DATA</u>
1	A	N
2	X	blank
3-5	I	Node number
6	X	blank
7-9	I	If a node number is coded in this field, the elevation and temperature data coded on the remainder of the card will be assigned to all node numbers from the node number coded in columns 3-5 to and including the node number coded in this field. If, for example, 10 is coded in columns 4 and 5 and 130 is coded in columns 7-9, then nodes 10 thru 130 would all have the elevation and temperature coded on the remainder of the card. Any of the consecutive numbers between 10 and 130 that are not actual node numbers assigned by the user are ignored. If columns 7-9 are left blank, the temperature and elevation data re-assigned only to the node whose number appears in columns 3-5.

CARD COLUMNS	FIELD TYPE	DATA
10	X	blank
11-18	F	X-elevation
19-26	F	Y-elevation
27-34	F	Z-elevation
35-42	F	Temperature, deg. F.
43-80	X	blank

#### 2.1.8 PRESSURE CARDS

PRESSURE cards are used to fix a pressure at a node.

CARD COLUMNS	FIELD TYPE	DATA
1	A	P
2	X	blank
3-5	I	Node number
6-8	X	blank
9-14	F	Pressure, psi (must be a positive number or zero)
15-80	X	blank

#### 2.1.9 TEMPERATURE CARDS

If no elevation data is to be input (see Sect. 2.1.8), the TEMPERATURE cards are used to specify the fluid temperatures at the nodes. If each node has a different fluid temperature, there will be as many TEMPERATURE cards (with all but the first node number field left blank) as there are nodes -- one for each node. If, however, several nodes have the same fluid temperature, those node numbers may be listed on a single TEMPERATURE card. If a number is coded in the first node number field, the second node number field is left blank, and a number is coded in the third node number field, all nodes having consecutive node numbers starting with the number in the first field and up to (and including) the number in the third field will be assigned the temperature that appears in the fluid temperature field of the card. If some of the intermediate numbers are not actual nodes, they are merely ignored.

CARD COLUMNS	FIELD TYPE	DATA
1	A	T
2-3	X	blank
4-6	I	First node number
7-8	X	blank
9-11	I	Second node number
12-13	X	blank
14-16	I	Third node number
17-18	X	blank
19-21	I	Fourth node number
22-23	X	blank
24-26	I	Fifth node number
27-28	X	blank
29-31	I	Sixth node number
32-33	X	blank
34-36	I	Seventh node number
37-38	X	blank
39-41	I	Eighth node number
42-43	X	blank
44-46	I	Ninth node number
47-48	X	blank
49-51	I	Tenth node number
52-53	X	blank
54-56	I	Eleventh node number
57-58	X	blank
59-61	I	Twelfth node number
62-65	X	blank
66-72	F	Fluid temperature, °F.
72-80	X	blank

Examples:

- (a) If a TEMPERATURE card has 16 coded in columns 5 and 6 and 1201.0 coded in columns 66 thru 71, a fluid temperature of 1201.0°F. will be assigned to node 16.

- (b) If a TEMPERATURE card has 10 coded in columns 5, and 6, a 55 coded in columns 10 and 11, a 105 coded in columns 14 thru 16, and 662.5 coded in columns 66 thru 70, then a fluid temperature of 662.5°F. will be assigned to nodes 10, 55, and 105.
- (c) If a TEMPERATURE card has 5 coded in column 6, 200 coded in columns 14 thru 16, and 1152.0 coded in columns 66 thru 71, then all nodes having node numbers between and including 5 and 200 will be assigned a fluid temperature of 1152.0°F.

## 2.2 PRINTED OUTPUT

MUFAN produces four types of printed output for each case: Card Input Listing, Member Flow Characteristics, Flow and Pressure Drop, and Pressure. Each type of printout is discussed in detail below and the printed output for a sample problem appears in Appendix A. The date (month/day/year) and the time of day (0000-2400) that the problem was run are printed at the top of each page of MUFAN printed output.

### 2.2.1 CARD INPUT LISTING

The cards in the deck for a case are listed exactly as they are punched. When errors in the data deck are detected by MUFAN, a descriptive error message is printed out and MUFAN skips to the next case (if any).

### 2.2.2 MEMBER FLOW CHARACTERISTICS

The following information is printed out for each member: member number (in ascending numerical order), type, length, outside diameter (D1), wall thickness, radius, angle, D2, roughness, Le/D, K-factor. Items in the preceding list that do not apply to a particular member are printed out as asterisks for that member. In the event that errors in the data are detected, MUFAN prints out a descriptive error message and skips to the next case (if any).

### 2.2.3 FLOW AND PRESSURE DROP

The flow rate (lb/hr) in each branch is printed out immediately followed by the pressure drop through each member on that branch. The pressure drop is also broken down into pressure drop due to changes in elevation



and pressure drop due to friction losses. Cumulative pressure drop along the branch is also printed out. Fixed flow rates, pressure drops and pressure rises are followed by an X. Free pressure drops are enclosed in parentheses.

#### 2.2.4 PRESSURE

The pressure at each node in the system is printed out. Fixed pressures are followed by an X.

#### 2.3 SAMPLE PROBLEM

The schematic for the system to be solved is shown in Figure 2. Node numbers have already been assigned. Additional system data appears in Figure 3.

Figure 4 contains the coding sheets filled out for this problem. The first card coded is the BEGIN card. A 1 in column 4 indicates that the fluid to be used is NaK, 1.0 in columns 15-17 indicates that there is a 1.0 g acceleration in the Y-direction, and 1 in column 60 indicates that the lengths, bend radii, and elevations are to be coded in inches. The remaining fields are left blank, which means that the default values shown in section 2.1.1 for the absolute error, relative error, and maximum number of iterations will be used. If for a problem which must be solved iteratively (such as this sample problem) it may be necessary to specify different values in order to get a satisfactory solution (see Section 3.3.1).

The next two cards coded are LABEL cards which provide a title to be printed at the top of each page of the printout. Since the HRPMA (185 to 10) is a pump, a pump type number is coded in column 45 of the MEMBER card. The upstream and downstream diameters and wall thicknesses are also coded. A CQ card gives the flow rates (in GPM) and a CP card gives the corresponding heads (in feet) for a type 1 pump. (Note that if there were other identical pumps in the system, they could all have a 1 coded in column 45 of their MEMBER cards and only the single set of

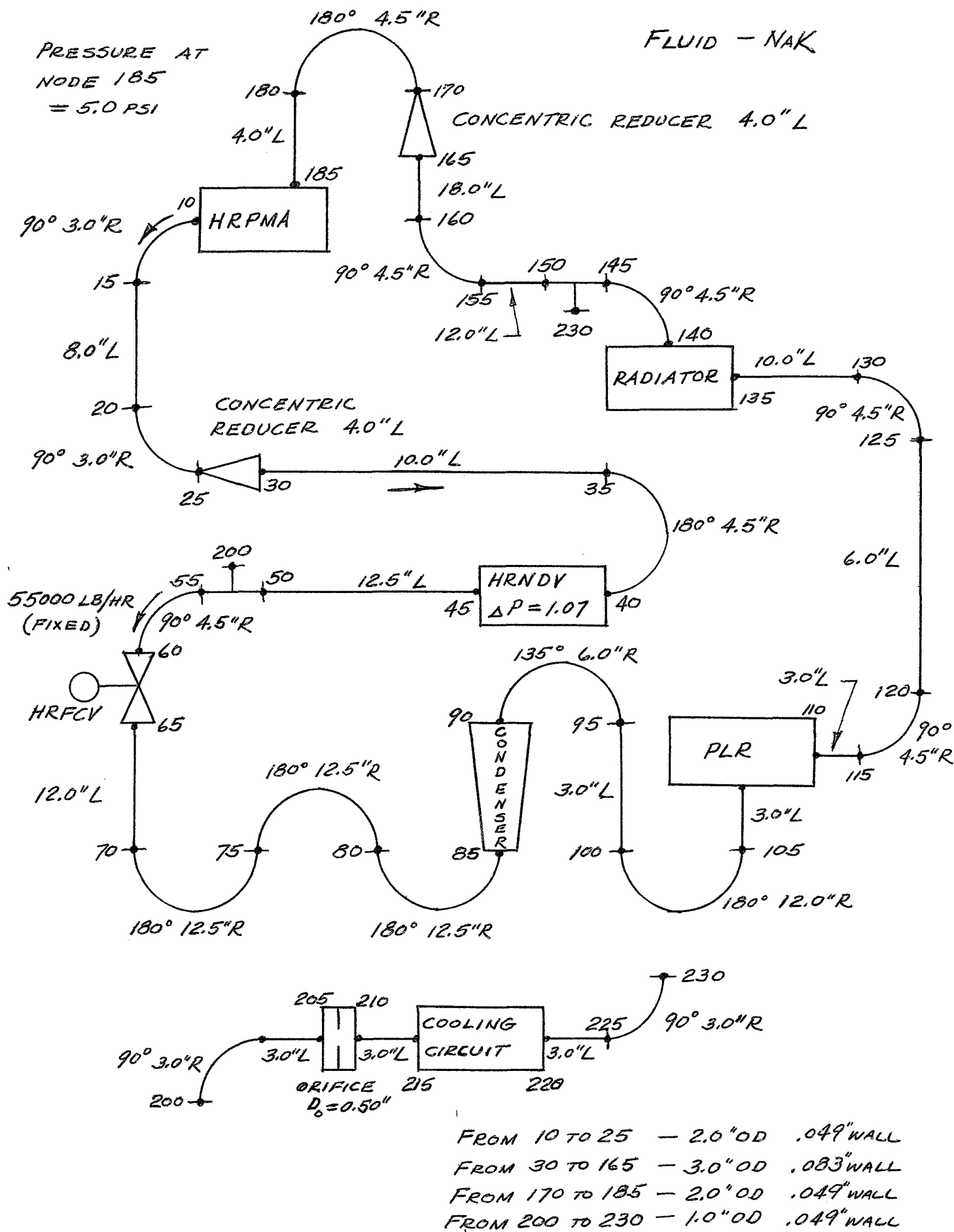


FIGURE 2 SYSTEM SCHEMATIC

FIGURE 3 - ADDITIONAL SYSTEM DATA

<u>Condenser</u>	
<u>Q, lb/hr</u>	<u>ΔP, psi</u>
30,000	2.3
40,000	3.5
54,000	6.4
70,000	12.5

<u>PLR</u>	
<u>Q, lb/hr</u>	<u>ΔP, psi</u>
32,000	0.33
40,000	0.48
48,000	0.70
56,000	1.00
65,000	1.35
70,000	1.56

<u>Radiator</u>	
<u>Q, lb/hr</u>	<u>ΔP, psi</u>
30,000	3.0
50,000	5.0
70,000	7.0

<u>Cooling Circuit</u>	
<u>Q, lb/hr</u>	<u>ΔP, psi</u>
0	0
4,000	16.0
8,000	64.0

<u>HRPMA</u>	
<u>Q, GPM</u>	<u>Head, ft.</u>
0	143
30	142
60	135
90	118
120	93
150	64
180	30

<u>Fluid Temperature</u>	
Nodes 10 thru 85	417°F
Nodes 90 thru 135	490°F
Nodes 140 thru 185	417°F

<u>Y Elevation</u>	
<u>Node(s)</u>	<u>Y, inches</u>
10 thru 85	40.0
90 thru 95	85.0
100 thru 120	75.0
125 thru 135	120.0
140 thru 185	40.0

L-30016

COMPUTING SCIENCES  
80 COLUMN INPUT

PROGRAM NO.

PROGRAMMED BY—

DATE 9/16/70 PROGRAM NO. 80 COLUMN INPUT PROGRAMMED BY D. Michaels Box 49

DATE 9/16/70 PROGRAM NO. 80 COLUMN INPUT PROGRAMMED BY D. Michaels Box 49

**STK, NO. D-1-083**

[illegible]

FIGURE 4 (PAGE 1 OF 3)

Figure 4

**COMPUTING SCIENCES  
80 COLUMN INPUT**

PROGRAM NO.

**PROGRAMMED BY—**

D, Michael's

DATE \_\_\_\_\_

9/16/70

[illegible]

8TK. NO. D-1-083

FIGURE 4 (PAGE 2 OF 3)

D. Michaels

DATE \_\_\_\_\_

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M 225	330	3.0	1.0	049	90:0	4
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M 230	1.50	1.0	.049	.083	3
M 230	1.50	1.0	.049	.083	3

CO CAMP	3	30000	50000	70000
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CP	C&P	3	3:0	5:0	7:0
CP	C&P	3	3:0	5:0	7:0

CO CAMP	4	0:0	4000:	8000:
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CP	C&MP	4	0:0	16:0	64:0
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413.0	85
413.0	85

[illegible]

185	417.0
140	417.0

1	200	239	450.9
2	200	239	450.9
3	200	239	450.9
4	200	239	450.9
5	200	239	450.9
6	200	239	450.9
7	200	239	450.9
8	200	239	450.9
9	200	239	450.9
10	200	239	450.9
11	200	239	450.9
12	200	239	450.9
13	200	239	450.9
14	200	239	450.9
15	200	239	450.9
16	200	239	450.9
17	200	239	450.9
18	200	239	450.9
19	200	239	450.9
20	200	239	450.9
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22	200	239	450.9
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26	200	239	450.9
27	200	239	450.9
28	200	239	450.9
29	200	239	450.9
30	200	239	450.9
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34	200	239	450.9
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36	200	239	450.9
37	200	239	450.9
38	200	239	450.9
39	200	239	450.9
40	200	239	450.9
41	200	239	450.9
42	200	239	450.9
43	200	239	450.9
44	200	239	450.9
45	200	239	450.9
46	200	239	450.9
47	200	239	450.9
48	200	239	450.9
49	200	239	450.9
50	200	239	450.9
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87	200	239	450.9
88	200	239	450.9
89	200	239	450.9
90	200	239	450.9
91	200	239	450.9
92	200	239	450.9
93	200	239	450.9
94			

N	19	85	40:0
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0.58 3.6 06 N

1	100	120	75.0
2	100	120	75.0
3	100	120	75.0
4	100	120	75.0
5	100	120	75.0
6	100	120	75.0
7	100	120	75.0
8	100	120	75.0
9	100	120	75.0
10	100	120	75.0
11	100	120	75.0
12	100	120	75.0
13	100	120	75.0
14	100	120	75.0
15	100	120	75.0
16	100	120	75.0
17	100	120	75.0
18	100	120	75.0
19	100	120	75.0
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41	100	120	75.0
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45	100	120	75.0
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57	100	120	75.0
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85	100	120	75.0
86	100	120	75.0
87	100	120	75.0
88	100	120	75.0
89	100	120	75.0
90	100	120	75.0
91	100	120	75.0
92	100	120	75.0
93	100	120	75.0
94	100	120	75.0
95	100	120	75.0
96	1		

	N	135	135	120.0
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	N	140	230	40-0	40-0
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P-1850

END

[illegible][illegible][illegible]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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[illegible][illegible]

STK. NO. D-1-083

STK. NO. D-1-083

FIGURE 4 (PAGE 3 OF 3)

CQ and CP shown would be required.) The concentric reducers are coded as a Gradual Expansion (22 in columns 48-49) in the case of member 25-30, and as a Gradual Contraction (21 in columns 48-49) in the case of member 165-170. The HRNDV is coded as having its K-factor input by the user (99 in columns 48-49); the K-factor is coded in columns 53-58.

Suppose we wish to find the pressure drop needed across the valve HRFCV such that the flow rate in that branch is 55,000 lb/hr. We can fix the flow rate in the branch by indicating a fixed flow rate (a 1 in column 44) on the MEMBER card for the first member in the branch, 50-55. We can then make member 60-65 a free pressure drop by coding a 2 in column 43 of its MEMBER card, and the program will compute the required pressure drop.

The Condenser, PIR, Radiator, and Cooling Circuit are coded as component types 1, 2, 3 and 4, respectively; and their characteristics are coded on the corresponding CQ and CP cards. Member 205-210 is coded as an orifice by coding 25 in columns 48-49 of its MEMBER card. The orifice diameter ( $D_o$ ) is coded in columns 53-58 and the outside diameter and wall thickness are coded in columns 25-30 and 31-36 respectively. Fluid temperature data is coded on TEMPERATURE cards and elevation data is coded on NODE cards. The pressure at node is 5.0 psi by a PRESSURE Card. A listing of the MUFAN computer program appears in Appendix A.

Suppose that the system to be analyzed contains liquid bismuth instead of liquid NaK. Liquid bismuth has the properties shown below (Ref. 9):

<u>Temp., °F.</u>	<u><math>\rho</math>, lb/ft<sup>3</sup></u>	<u><math>\mu</math>, lb/sec-ft</u>
600	625	$1.09 \times 10^{-3}$
800	616	$0.90 \times 10^{-3}$
1000	608	$0.74 \times 10^{-3}$
1200	600	$0.62 \times 10^{-3}$
1400	591	$0.53 \times 10^{-3}$

A 6 would be coded in column 4 of the BEGIN card and FT, FD, and FV cards would be coded as shown in figure 5. Note that the viscosity data must be converted to lb/hr-ft.

COMPUTING SCIENCES  
80 COLUMN INPUT

DATE \_\_\_\_\_

PROGRAM NO.

PROGRAMMED BY

D. Michaels

[illegible]

Figure 5 Input Card for Temperature, Density and Viscosity of Liquid Bismuth



## 2.4 LIMITATIONS

The following limitations apply to the current version of MUFAN:

- (a) Node numbers must be integers between (and including) 1 and 500.
- (b) The maximum number of members allowed is 600.
- (c) The maximum number of Branches allowed is 150.
- (d) The maximum number of Branch Points allowed is 100.
- (e) Pressure cannot be fixed at a Branch Point.
- (f) An open Branch must have either a fixed flow rate and/or have the pressure at its End Point fixed.

## 3.0 ANALYSIS

The problems handled by MUFAN are limited to those involving one dimensional incompressible steady state fluid flow. The approach taken involves an application of the Bernoulli equation:

$$(3.1) \quad Z_1 + \frac{P_1}{144\rho_1} + \frac{V_1^2}{288g} = Z_2 + \frac{P_2}{144\rho_2} + \frac{V_2^2}{288g} + \Delta h_{12}$$

Where:  $Z$  = elevation, ft.

$P$  = pressure, psi

$\rho$  = weight density, lb/ft<sup>3</sup>

$V$  = bulk velocity, ft/sec

$g$  = gravitational acceleration, ft/sec/sec.

$\Delta h_{12}$  = friction head loss between 1 and 2, ft.

Subscript 1 denotes the upstream station and subscript 2 denotes the downstream station. Use is also made of the continuity equation:

$$(3.2) \quad \rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

Where:  $A$  = area, ft<sup>2</sup>

If we assume that the density is the same at stations 1 and 2, that is:

$$\rho_1 = \rho_2 = \rho_{12}$$

we can rewrite equation 3.1 as:

$$(3.3) \quad 144\rho_{12} Z_1 + P_1 + \frac{\rho_{12} V_1^2}{2g} = 144\rho_{12} Z_2 + P_2 + \frac{\rho_{12} V_2^2}{2g} + \Delta P_{12}$$

Where:  $\Delta P_{12} = 144 \rho_{12} \Delta h_{12}$   $\Delta h_{12}$  = friction head loss, psi

The subscript 12 denotes properties of the member connecting stations 1 and 2. It is convenient to define a fluid resistance,  $r_{12}$ , as follows:

$$(3.4) P_1 + 144 \rho_{12} Z_1 = P_2 + 144 \rho_{12} Z_2 + r_{12} Q$$

Where:  $r_{12}$  = resistance, psi-hr/lb

$Q$  = weight flow rate, lb/hr

$$= 3600 \rho_{12} A_1 V_1 = 3600 \rho_{12} A_2 V_2$$

Then, from 3.3 and 3.4:

$$(3.5) r_{12} = \frac{1}{Q} \left[ \frac{\rho_{12} (V_2^2 - V_1^2)}{2g} + \Delta P_{12} \right]$$

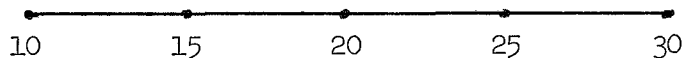
For members having the areas at stations 1 and 2 equal, 3.5 reduces to:

$$(3.6) r_{12} = \frac{\Delta P_{12}}{Q}$$

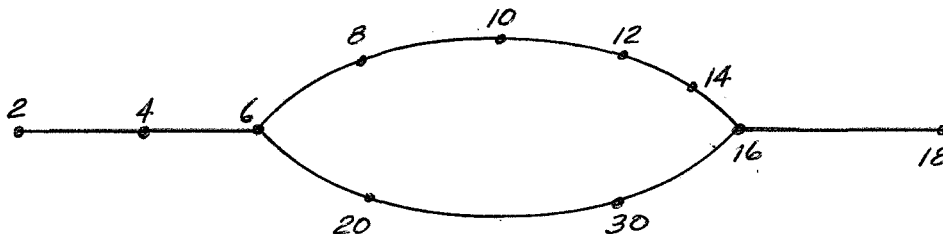
A Branch is a line consisting of one or more members connected end to end. The weight flow rate in each member of a Branch is the same (from continuity; equation 3.2). The system to be analyzed may consist either of a single branch, or, of three or more branches connected to form a network. The points at which three or more branches meet are called Branch points.

Examples:

Branch



System with 4 Branches and 2 Branch Points



If a node is connected to only one other node, then it is an End Point. Both examples above have 2 End Points each. The resistances of the members in a Branch may be summed along the Branch to give the total resistance of the Branch,  $R$ ; and, the elevation head at each node in the branch (relative to the node preceding it in the branch) may be summed to give the elevation head of the end of the branch relative to the beginning of the branch,  $E$ :

$$(3.7) \quad R_{IJ} = \sum_{i=1}^{n-1} r_{i, i+1}$$

$$(3.8) \quad E_{IJ} = \sum_{i=1}^{n-1} \rho_{i, i+1} (Z_{i+1} - Z_i)$$

The subscripts on  $R$  and  $E$  indicate that the Branch connects Branch (or End) Point  $I$  to Branch (or End) Point  $J$ . The fluid conductance of a branch is:

$$(3.9) \quad G_{IJ} = \frac{1}{R_{IJ}}$$

The net flow out of each Branch Point must be zero. This requirement is satisfied for the  $I^{\text{th}}$  Branch Point if:

$$(3.10) \quad \sum_{\substack{J \\ J \neq I}} G_{IJ} [P_I - P_J \pm (E_{IJ} + \Delta P_{IJ})] - \sum_K \pm Q_{IK} = 0$$

Where:  $P_I$  = pressure at Branch Point  $I$

$P_J$  = pressure at Branch Point  $J$

$\Delta P_{IJ}$  = pump pressure rise and/or fixed pressure rise on Branch  $IJ$  (if any)

$Q_{IK}$  = fixed flow rate in Branch  $IK$

The index J runs over all Branch Points (and End Points) connected to Branch Point I by a Branch not having a fixed flow rate; the index K runs over all Branch Points (and End Points) connected to Branch Point I by a Branch having a fixed flow rate. The signs in front of  $E_{IJ}$ ,  $\Delta P_{IJ}$  and  $Q_{IK}$  are positive if the positive direction of flow in a Branch is from J (or K) to I. The positive direction of flow in a branch depends on how the members are coded (see section 2.0).

The solution of the set of equations 3.10 proceeds as follows:

(a) An initial guess is made for the values of the flow rates in all the Branches with non-fixed flow rates.

(b) In each of the Branches with non-fixed flow rates the current estimate of the flow rate in that Branch is used to compute the conductance of the Branch.

(c) The set of equations (3.10) is set up and solved for the Branch Point pressures.

(d) The new values of the Branch Point pressures along with the current values of the Branch conductances are used to compute a new estimate for the flow rate in each Branch not having a fixed flow rate.

Steps b through d are repeated until successive estimates of each Branch flow rate agree sufficiently.

The sections which follow contain a more detailed discussion of the items discussed.

### 3.1 FRICTION HEAD LOSS COMPUTATIONS

The method by which the friction head loss through a member is computed depends on the type of member. Three distinct methods are used:

$$(3.11) \quad \Delta P = K \frac{\rho V^2}{288g}$$

$$(3.12) \quad \Delta P = f \frac{L}{D} \frac{\rho V^2}{288g}$$

$$(3.13) \quad \Delta P = F(Q)$$

Where:  $\Delta P$  = friction head loss, psi

$K$  = K-factor, dimensionless

$f$  = friction factor, dimensionless

$L$  = length, ft.

$D$  = diameter, ft.

$\rho$  = weight density, lb/ft<sup>3</sup>

$V$  = bulk velocity, ft/sec

$g$  = gravitational acceleration, ft/sec/sec

$F(Q)$  = a relationship between  $\Delta P$  and  $Q$  which is specified  
by tabular data (see section 2.1.2)

$Q$  = weight flow rate, lb/hr

### 3.1.1 K-FACTORS

The K-factors listed in Table 1 below are computed by the program from input supplied by the user. In the table below the velocity used to compute the friction head loss in equation 3.11 is identified as either 1 for inlet velocity or 2 for outlet velocity. K-factors which are not given by a constant, a simple table of values, or an algebraic expression are given in Appendix B. In the descriptions below "Tubing" refers to fittings having wall roughness on the order of smooth tubing, while "piping" refers to fittings having wall roughness on the order of cast pipe. Linear interpolation is used in the tables for pipe fittings to determine K-factors for

intermediate values of inside diameter. Fittings with inside diameters less than 0.5 inches are assigned the K-factor for 0.5 inches; fittings with inside diameters greater than 4.0 inches are assigned the K-factor for 4.0 inches.

TABLE 1 - K-FACTORS

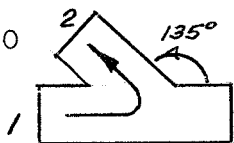
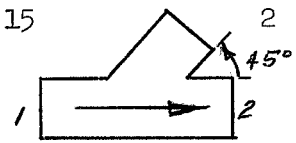
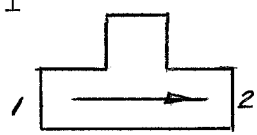
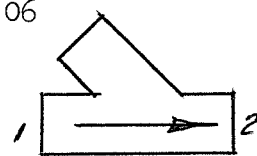
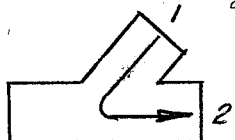
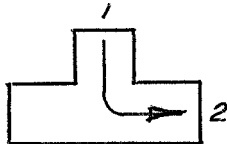
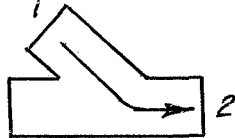
<u>Description</u>	<u>Velocity</u>	<u>K-factor</u>	<u>Ref.</u>
30° or 45° Tubing branch -flow out thru branch	1	(See Appendix B)	1
60° Tubing branch - flow out thru branch	1	(See Appendix B)	1
90° Tubing branch - flow out thru branch	1	(See Appendix B)	1
45° Tubing branch from 90° elbow - flow out thru branch	1	(See Appendix B)	1
7° Tubing branch from 90° elbow - flow out thru branch	1	(See Appendix B)	1
15° Tubing branch from 155° elbow - flow out thru branch	1	(See Appendix B)	1
135° Tubing branch - flow out thru branch	1	K=3.0	2
			
45° Tubing branch - flow thru main	1	K=0.15	2
			
90° Tubing branch - flow thru main	1	K=0.1	2
			
135° Tubing branch - flow thru main	1	K=0.06	2
			
45° Tubing branch - flow in thru branch	1	K=3.0	2
			

TABLE 1 - K-FACTORS (continued)

Description	Velocity	K-factor	Ref.										
90° Tubing branch - flow in thru branch	1	K=1.2	2										
													
135° Tubing branch - flow in thru branch	1	K=0.5	2										
													
Tubing bend, 0 deg.	1	(See Appendix B)	3										
90° standard piping elbow	1	<table><tr><td>I.D.</td><td>0.5</td><td>1.0</td><td>2.0</td><td>4.0</td></tr><tr><td>K</td><td>0.82</td><td>0.68</td><td>0.58</td><td>0.50</td></tr></table>	I.D.	0.5	1.0	2.0	4.0	K	0.82	0.68	0.58	0.50	2
I.D.	0.5	1.0	2.0	4.0									
K	0.82	0.68	0.58	0.50									
45° standard piping elbow	1	<table><tr><td>I.D.</td><td>0.5</td><td>1.0</td><td>2.0</td><td>4.0</td></tr><tr><td>K</td><td>0.43</td><td>0.36</td><td>0.30</td><td>0.26</td></tr></table>	I.D.	0.5	1.0	2.0	4.0	K	0.43	0.36	0.30	0.26	2
I.D.	0.5	1.0	2.0	4.0									
K	0.43	0.36	0.30	0.26									
90° long piping elbow	1	<table><tr><td>I.D.</td><td>0.5</td><td>1.0</td><td>2.0</td><td>4.0</td></tr><tr><td>K</td><td>0.55</td><td>0.45</td><td>0.38</td><td>0.33</td></tr></table>	I.D.	0.5	1.0	2.0	4.0	K	0.55	0.45	0.38	0.33	2
I.D.	0.5	1.0	2.0	4.0									
K	0.55	0.45	0.38	0.33									
Standard piping tee - flow thru main	1	<table><tr><td>I.D.</td><td>0.5</td><td>1.0</td><td>2.0</td><td>4.0</td></tr><tr><td>K</td><td>0.55</td><td>0.45</td><td>0.38</td><td>0.33</td></tr></table>	I.D.	0.5	1.0	2.0	4.0	K	0.55	0.45	0.38	0.33	2
I.D.	0.5	1.0	2.0	4.0									
K	0.55	0.45	0.38	0.33									
Standard piping tee - flow thru branch	1	<table><tr><td>I.D.</td><td>0.5</td><td>1.0</td><td>2.0</td><td>4.0</td></tr><tr><td>K</td><td>1.7</td><td>1.4</td><td>1.2</td><td>1.0</td></tr></table>	I.D.	0.5	1.0	2.0	4.0	K	1.7	1.4	1.2	1.0	2
I.D.	0.5	1.0	2.0	4.0									
K	1.7	1.4	1.2	1.0									
Close return piping bend	1	<table><tr><td>I.D.</td><td>0.5</td><td>1.0</td><td>2.0</td><td>4.0</td></tr><tr><td>K</td><td>1.4</td><td>1.2</td><td>0.96</td><td>0.82</td></tr></table>	I.D.	0.5	1.0	2.0	4.0	K	1.4	1.2	0.96	0.82	2
I.D.	0.5	1.0	2.0	4.0									
K	1.4	1.2	0.96	0.82									
Gradual contraction	2	(See Appendix B)	2										
Gradual expansion	1	(See Appendix B)	2										
Sudden contraction	2	(See Appendix B)	2										
Sudden expansion	1	$K = \left(1 - \frac{A_1}{A_2}\right)^2$	2										
Orifice	1	(See Appendix B)	4, 7										



### 3.1.2 EQUIVALENT LENGTHS

The equivalent lengths ( $Le/D$ ) listed in table 2 below are computed by the program from input supplied by the user. The following relationships are used by the program to compute the friction factor: (Reference 6):

$$(3.14) \quad R = \frac{48Q}{3600 \pi D \mu}$$

$$(3.15) \quad f = \frac{64}{R} \quad \text{for } R \leq 2100$$

$$(3.16) \quad \frac{1}{\sqrt{f}} = 2 \log_{10} \left( \frac{D}{e} \right) + 1.14 - 2 \log_{10} \left[ 1 + \frac{9.28}{R \left( \frac{e}{D} \right) \sqrt{f}} \right]$$

for  $R \leq 4000$

Where:  $R$  = Reynold's number

$Q$  = Weight flow rate, lb/hr

$D$  = Inside diameter, in.

$\mu$  = Viscosity, lb/ft-hr.

$f$  = friction factor

$e$  = Roughness, in.

In the transition region ( $2100 < R < 4000$ ) interpolation is performed between the value of the friction factor at  $R=2100$  and the friction factor at  $R=4000$ .

The equivalent length values in Table 2 are for fully turbulent flow. A correction is made for laminar flow as follows (Reference 4):

$$(3.17) \quad (Le/D)_{\text{LAMINAR}} = \frac{R}{1000} (Le/D)_{\text{TURBULENT}}$$

for  $R < 1000$

The equivalent length and friction factor values described above are used in equation 3.12 to compute the friction head loss.

TABLE 2 - EQUIVALENT LENGTHS

<u>Description</u>	<u>Le/D</u>	<u>Ref.</u>
Straight pipe	(Pipe Length)/(Inside diameter)	
Tubing bend, $\theta$ deg.	$(Le/D) = 0.0202 \times \theta^{1.10} R^{0.032}$	5
	$\frac{r/D}{X} \begin{array}{cccccc} 1.0 & 1.5 & 2.0 & 2.5 & 3.0 & 4.0 \\ 3.0 & 1.7 & 1.3 & 1.2 & 1.3 & 1.8 \end{array}$ $\frac{r/D}{X} \begin{array}{ccc} 5.0 & 6.0 & 7.5 \\ 2.1 & 2.7 & 3.5 \end{array}$	
	$X = 0.482 \ r/D \text{ for } r/D > 7.5$	
	$r = \text{Bend radius}$	
	$D = \text{inside diameter}$	
	$R = \text{Reynold's number}$	
90° standard pipe elbow	$(Le/D) = 30.0$	2
45° standard pipe elbow	$(Le/D) = 16.0$	2
90° Long pipe elbow	$(Le/D) = 20.0$	2
Close return pipe bend	$(Le/D) = 50.0$	2
Gate Valve	$(Le/D) = 13.0$	2
Swing Check	$(Le/D) = 135.0$	2
Angle Valve	$(Le/D) = 145.0$	2
Globe Valve	$(Le/D) = 340.0$	2
Standard pipe tee - flow thru main	$(Le/D) = 20.0$	2
Standard pipe tee - flow thru branch	$(Le/D) = 60.0$	2

### 3.2 FLUID DENSITY AND VISCOSITY

The density and viscosity (as a function of temperature) of NaK, liquid mercury, and 4P3E used by MUFAN was obtained from reference (8); that of liquid water was obtained from reference (9). The data is coded in tabular form in the program and subroutine INT<sup>4</sup> (see ref. 10) is used to perform interpolation in the tables.

### 3.3 SOLUTION PROCEDURE

The set of equations represented by (3.10) may be written in matrix form as follows:

$$(3.18) \quad \begin{bmatrix} b_{11} & b_{12} & . & . & . & b_{1N} \\ b_{21} & b_{22} & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ b_{NI} & . & . & . & . & b_{NN} \end{bmatrix} \begin{Bmatrix} P_1 \\ P_2 \\ . \\ . \\ . \\ P_N \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ . \\ . \\ . \\ F_N \end{Bmatrix}$$

Where: N = number of Branch Points

$$b_{II} = \sum_{J=1}^{N+M} G_{IJ}$$

$$b_{IJ} = -G_{IJ}$$

M = number of End Points

$P_I$  = pressure at Branch Point I

$$F_I = - \sum_{\substack{J=1 \\ J \neq K}}^N \pm G_{IJ} (E_{IJ} + \Delta P_{IJ}) + \sum_K \pm Q_{IK} \\ + \sum_{\substack{L=N+1 \\ L \neq K}}^{N+M} G_{IL} \left[ P_L \pm (E_{IJ} + \Delta P_{IJ}) \right]$$

$P_L$  = fixed pressure at an End Point

Gaussian elimination (with pivoting) is used to solve the system of equations (3.18) for  $P_1, \dots, P_N$ . The new estimate for the flow rate in each Branch not having a fixed flow rate is computed as:

$$(3.19) \quad Q'_{IJ} = \frac{1}{2} \left\{ Q_{IJ} \pm G_{IJ} \left[ P_I - P_J \pm (E_{IJ} + \Delta P_{IJ}) \right] \right\}$$

Where:  $Q'_{IJ}$  is the new flow rate estimate

$Q_{IJ}$  is the old flow rate estimate

The  $Q'_{IJ}$  are used to compute a new set of  $G_{IJ}$  and pump  $\Delta P$ 's which are in turn substituted in the system of equations (3.18) which are solved for a new set of  $P_I$ 's,  $\dots$  etc. This process continues until sufficient convergence of flow rates is obtained.

### 3.3.1 CONVERGENCE CRITERIA

In any iterative solution process it is necessary to have some method of deciding when a sufficiently accurate solution has been achieved or, failing this, a method of terminating the process after some reasonable number of steps. A good estimate of the accuracy of the solution at any point is the "closeness" of two successive estimates of flow rates. The iterative process is terminated if either of the following relationships hold for each Branch in the system:

$$\left| Q'_{IJ} - Q_{IJ} \right| \leq \epsilon_A,$$

or,

$$\left| \frac{Q'_{IJ} - Q_{IJ}}{D} \right| \leq \epsilon_R$$

Where:  $Q'_{IJ}$  is the new estimate for the flow rate in Branch IJ

$Q_{IJ}$  is the old estimate for the flow rate in Branch IJ

$\epsilon_A$  is the absolute error tolerance

D is the smaller of  $Q'_{IJ}$

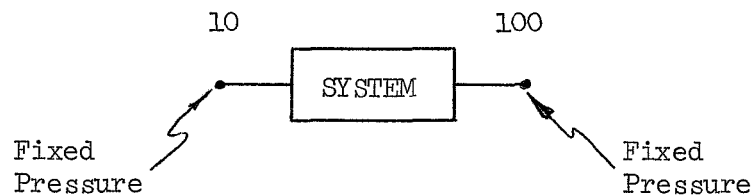
and  $Q_{IJ}$

$\epsilon_R$  is the relative error tolerance

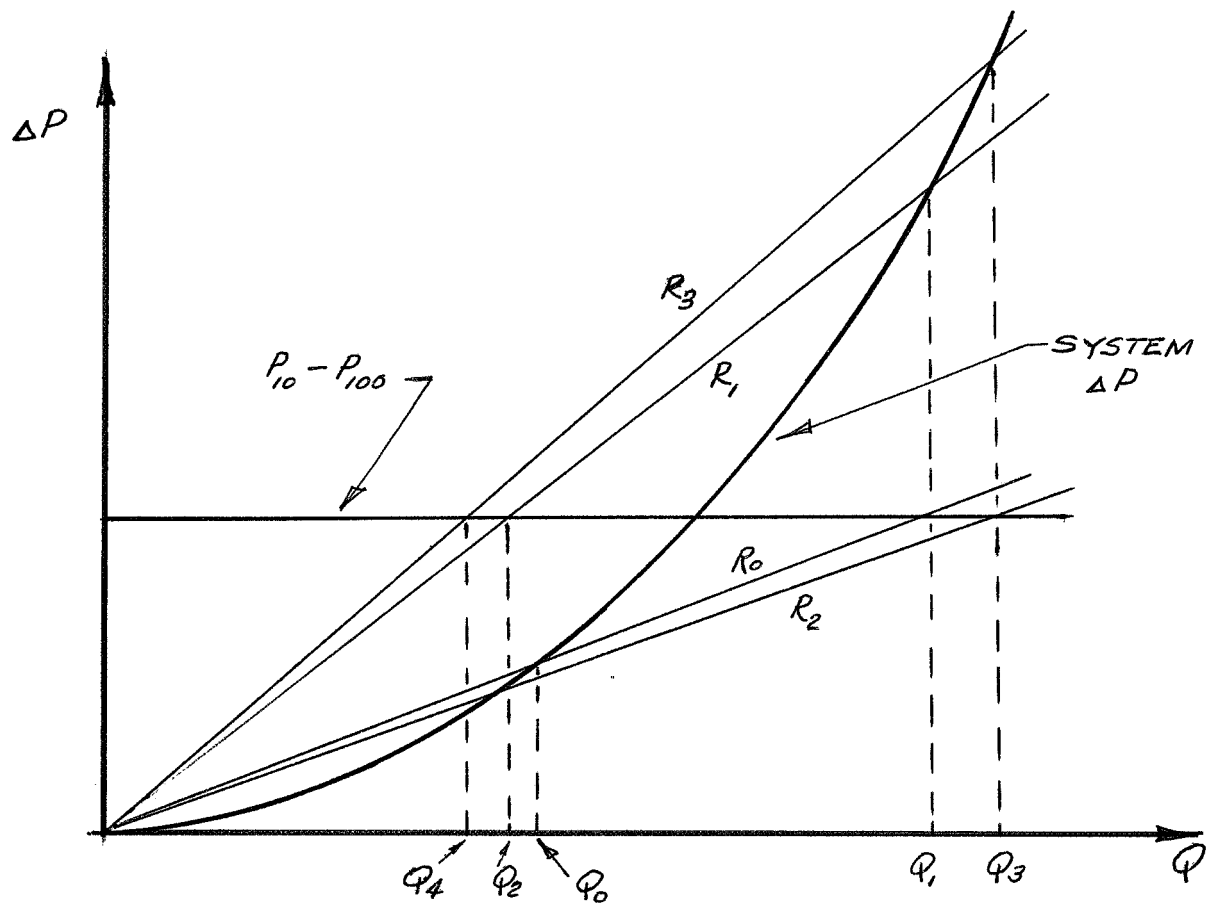
If the criteria given above are not met after the number of iterations specified by the user have been performed, the iteration process is halted and an error message is printed.

### 3.3.2 STABILITY AND RATE OF CONVERGENCE

As an illustration of the behavior of the iteration procedure, consider a system with a fixed pressure drop across it.



Starting with an initial estimate of the flow rate,  $Q_0$ , the resistance is determined. Using the resistance and the fixed pressure drop a new estimate of the flow rate,  $Q_1$ , is determined, . . . etc. A graphical example of this process follows.

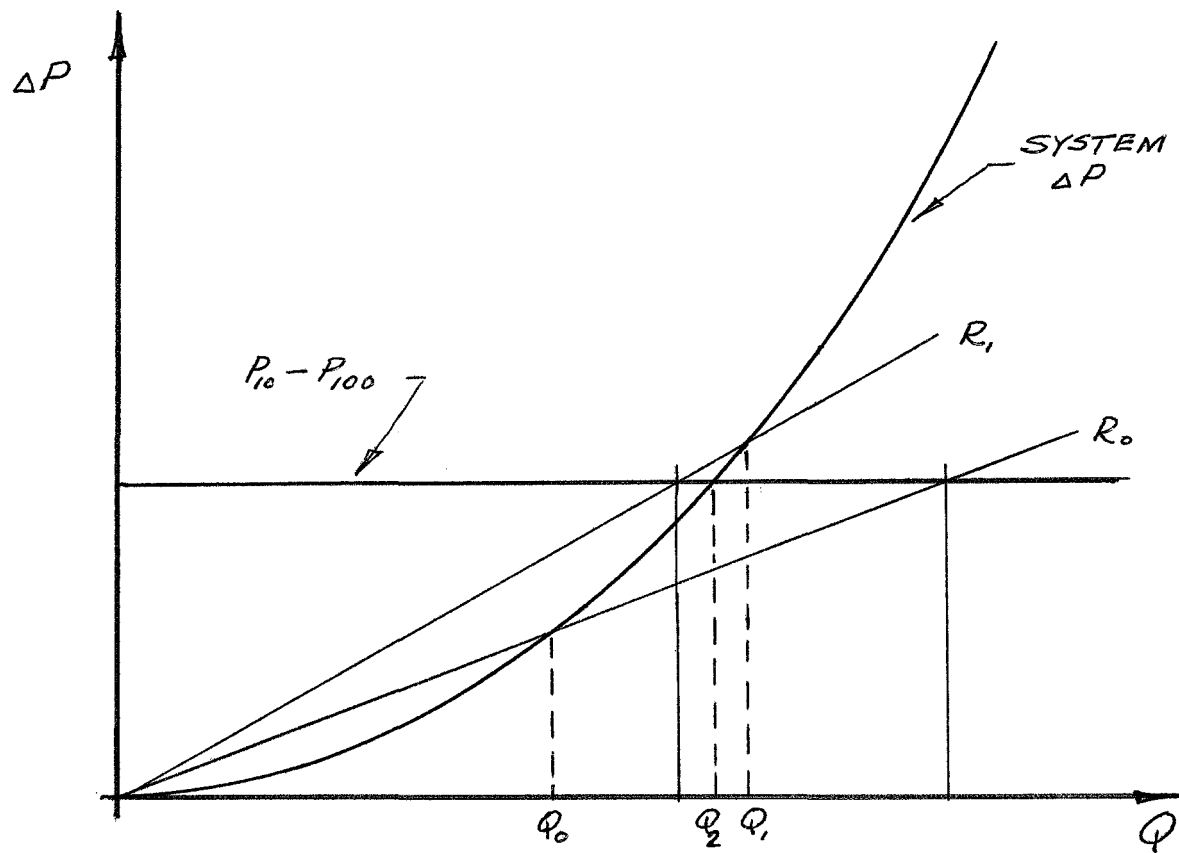


It is evident from the first four iterations that the process is diverging from the solution. In order to remedy this situation, let the new estimate for the flow rate be:

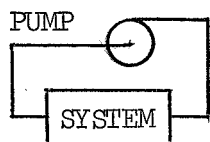
$$Q_{n+1} = \frac{1}{2} (Q_n + Q'_{n+1})$$

Where:  $Q'_{n+1}$  is the flow rate determined by the method used above.

A graphical example with this new flow rate follows.



It is evident that this modified iteration procedure converges rapidly to the correct solution. As a further illustration of the behavior of the iteration procedure, consider a system with a pump.

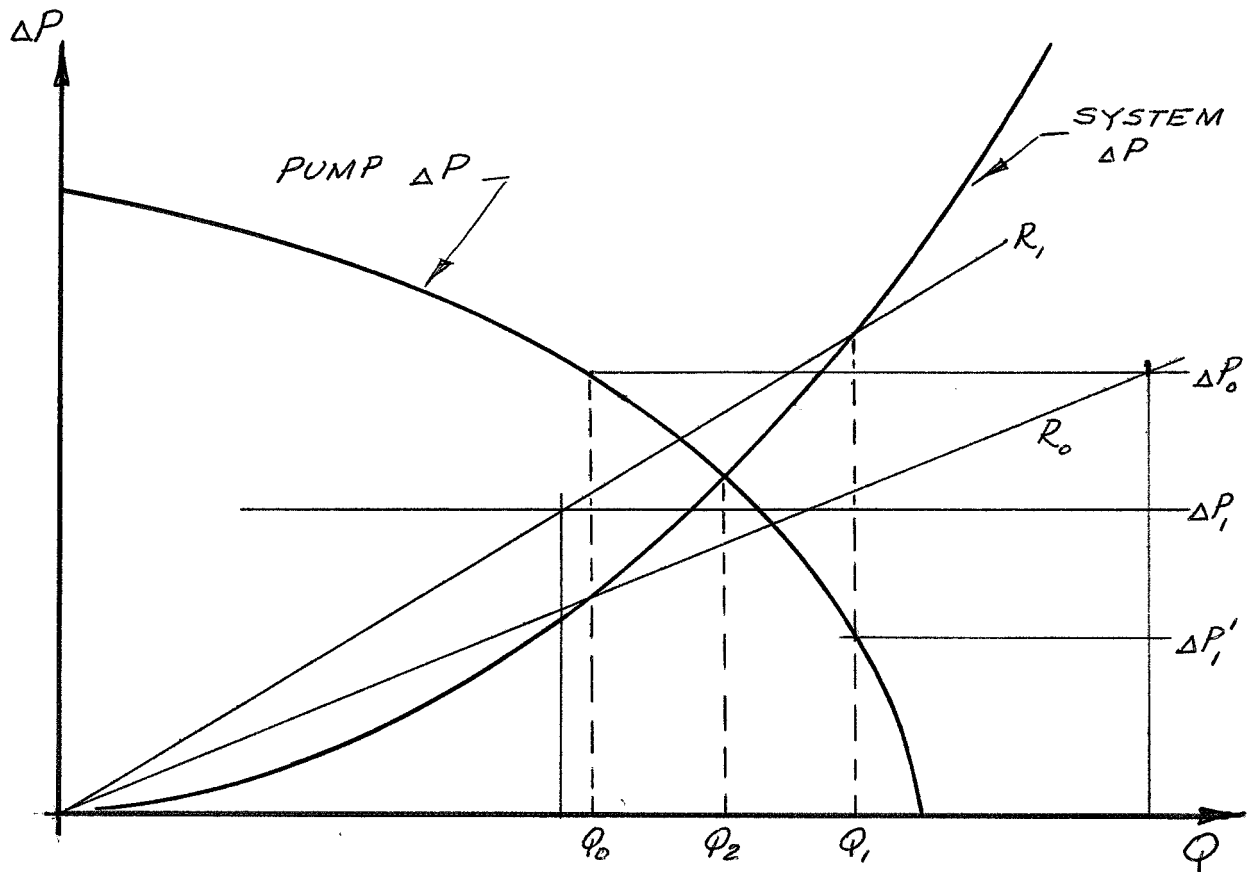


Starting with an initial estimate of the flow rate,  $Q_0$ , the resistance and the pump  $\Delta P$  are determined. Using the resistance and the pump  $\Delta P$  a new estimate of the flow rate,  $Q_1$ , is determined, . . . etc. All pump  $\Delta P$ 's after the initial one are computed as:

$$\Delta P_{N+1} = \frac{1}{2} (\Delta P_N + \Delta P'_{N+1})$$

Where  $\Delta P'$  is the value of pump  $\Delta P$  which corresponds to  $Q_{N+1}$ .

A graphical example of this process appears below.



The example indicates that the iteration process converges to the solution rapidly.



REFERENCES

- (1) Daniels, C.M. and Pelton, H.A., "Pressure Losses in Hydraulic Branch-Off Fittings", Product Engineering, July 20 1959, pp. 61-62.
- (2) Dodge, L., "Local Resistance + Fluid Flow", Product Engineering, March 2, 1964.
- (3) North American Aviation Report 1808, 1951.
- (4) Crane Technical Paper No. 410, "Flow of Fluids", Crane Industrial Products Group, 1957.
- (5) Perry, J. H., Chemical Engineer's Handbook, McGraw Hill, 1950, p. 390.
- (6) Streeter, V. L., Handbook of Fluid Dynamics, McGraw Hill, 1961, pp. 3-12, -14.
- (7) Spink, L.K., Principles of Flowmeter Engineering, The Foxboro Co., 1958, p. 25.
- (8) Aerojet-General Corp. Design Manual H-100B, "Properties of Fluids", section IV-2, 19 February 1968.
- (9) Kreith F., Principals of Heat Transfer, International Textbook Co., 1964, p. 537.
- (10) Programmer's Reference Manual, Computing Sciences Dept., Aerojet-General Corp., Azusa, 1970, pp. 25.13-1, -2.

## APPENDIX A

### MUFAN Program Listings

OLD VOL=SER=004783

**DRC UPDATE**

NEW VOL=SER=007208

DESQ

MESSAGE

FILENAME=MUFAN

DECKNAME=

YY.DD[

```
CTRL CARD      . / ADD MUFAN,TYPE=SOURCE
CIRI CARD      - / ADD MUFAN(MUFAN).FORT,RESEQ,LIST
```

CTRI CARD . /ADD MUFAN,TYPE=SOURCE

DATE	DESCRIPTION	AMOUNT	BALANCE
10/1/20	OPENING BALANCE		70.29
10/5/20	PAYROLL	100.00	170.29
10/10/20	RENT	50.00	120.29
10/15/20	SALES TAX	25.00	95.29
10/20/20	UTILITIES	15.00	80.29
10/25/20	INSURANCE	10.00	70.29
10/31/20	CLOSING BALANCE		70.29

ADDED  
C  
C  
00000200  
70.29

[illegible]

ADDED C C \*\* \*\* \*\* \*\*

[illegible]

ADDED C \* \* \* \* \* 00000600 70.29

ADDED	C	*	*	*	*	*	*	*
00000700	C	*	*	*	*	*	*	*
70.29								

ADDED C \* \* \* \* \* 00000800 70.29

ADDED	C	*	*	*	*	*	*	*	*	*
0000900	70.29	*	*	*	*	*	*	*	*	*

ADDED	C	00001000	70.29
ADDED	C	00001000	70.29

ADDED	C	MULTI-LOOP FLUID FLOW ANALYSIS PROGRAM	00001100	70.29
-------	---	--	----------	-------

ADDED	C	FOR ANALYSIS OF ONE-DIMENSIONAL	INCOMPRESSIBLE	70.29
00001200				

ADDED	C	STEADY-STATE FLUID FLOW	70.29
ADDED	C	00001300	00001300

ADDED	C	VERSION 1	BY DAN MICHAELS	10/8/70	00001400	70.29
-------	---	-----------	-----------------	---------	----------	-------

ADDED	C	00001500	70.29
ADDED	C	00001500	70.29

ADDED  
C-----00001600 70.29  
C-----00001600 70.29

ADDED	REAL#8	DATE	00001700	70.295
ADDED	REAL#8	DATE	00001700	70.295

ADDED	COMMON	/MUFCOM/	00001800	70.29
-------	--------	----------	----------	-------

```

ADDED      1 A(3),          YOLABS,          CONSTS(3,600), GC,    70.29
           1 A(3),          YOLABS,          CONSTS(3,600), GC,    00001900

```

ADDED	2	IBCON(600),	IBRAN(850),	IFLUID,	IOPT(10),	00002000	70.29

```

ADDED 3 ITEM, JBRPT(600), LABEL(20,3), 00002100 70.29
ADDED 3 ITEM, TYPE(600), 00002100 70.29

```

ADDED	LEVEL,	MBRAN( 850),	NBCON( 250),	NBRAN,	70.29
4	4				00002200
					00002200

ADDED	5	NBRPTS,	NNMAX,	NPTS(150),	PBRPT(250),	00002300	70.295
-------	---	---------	--------	------------	-------------	----------	--------

ADDED	6	QBR(150),	QERR,	RHO(600),	TBULK(500),	00002400	70.29
-------	---	-----------	-------	-----------	-------------	----------	-------

ADDED	7	TOLERR	VISC(600),	XDOTA(500)	00002500	70.29

```

COMMON /MUFCOM/
      INOUT(100);
      NDUMBP;
      LDDP
      00002600
      70.29

```

ADDED	COMMON	/PUNT/	MMEM,MNODES,	DATE
				00002700
				70.29

	ADDED	COMMON / UNIT / TIME			
			70.29		
			00002800		
			00002800		
			00002800		
			70.29		

```
ADDED
EQUIVALENCE
(LIMIT,I)PI(I), (INF,I)PI(2)
00002900
70.29
```

[illegible]

ADDED  
TO CONTINUE

[illegible]

ADDED  
JULEKK=0001  
70CZ9

ADDED	70.29
00003400	70.29
00003500	70.29
00003600	70.29
00003700	70.29
00003800	70.29
00003900	70.29
00004000	70.29
00004100	70.29
00004200	70.29
00004300	70.29
00004400	70.29
00004500	70.29
00004600	70.29
00004700	70.29
00004800	70.29
00004900	70.29
00005000	70.29
00005100	70.29
00005200	70.29
00005300	70.29
00005400	70.29
00005500	70.29
00005600	70.29
00005700	70.29
00005800	70.29
00005900	70.29
00006000	70.29
00006100	70.29
00006200	70.29
00006300	70.29
00006400	70.29
00006500	70.29
00006600	70.29
00006700	70.29
00006800	70.29
00006900	70.29
00007000	70.29
00007100	70.29
00007200	70.29
00007300	70.29
00007400	70.29
00007500	70.29
00007600	70.29
00007700	70.29
00007800	70.29
00007900	70.29
00008000	70.29
00008100	70.29
00008200	70.29
00008300	70.29
00008400	70.29
00008500	70.29
00008600	70.29
00008700	70.29
00008800	70.29
00008900	70.29
00009000	70.29
00009100	70.29
00009200	70.29
00009300	70.29
00009400	70.29
00009500	70.29
00009600	70.29
00009700	70.29
00009800	70.29
00009900	70.29
00010000	70.29
00010100	70.29
00010200	70.29
00010300	70.29
00010400	70.29
00010500	70.29
00010600	70.29
00010700	70.29
00010800	70.29
00010900	70.29
00011000	70.29
00011100	70.29
00011200	70.29
00011300	70.29
00011400	70.29
00011500	70.29
00011600	70.29
00011700	70.29
00011800	70.29
00011900	70.29
00012000	70.29
00012100	70.29
00012200	70.29
00012300	70.29
00012400	70.29
00012500	70.29
00012600	70.29
00012700	70.29
00012800	70.29
00012900	70.29
00013000	70.29
00013100	70.29
00013200	70.29
00013300	70.29
00013400	70.29
00013500	70.29
00013600	70.29
00013700	70.29
00013800	70.29
00013900	70.29
00014000	70.29
00014100	70.29
00014200	70.29
00014300	70.29
00014400	70.29
00014500	70.29
00014600	70.29
00014700	70.29
00014800	70.29
00014900	70.29
00015000	70.29
00015100	70.29
00015200	70.29
00015300	70.29
00015400	70.29
00015500	70.29
00015600	70.29
00015700	70.29
00015800	70.29
00015900	70.29
00016000	70.29

ADDED	PLACES	REMAINING	TO ABS	TO END	NET
ADDED	5000				00002600
					00003300
					00003500
					70.29
					70.20

[illegible]

ADDED  
ADDED  
FUKUOKA  
CALLE  
DATE

ADDED	CALL	EDIDAT(DATE)
000003800	00.27	

LD SEQ	MESSAGE	FILENAME=MUFAN	DRC UPDATE	NEW VOL=SER=007208	YY.DD
	ADDED	CALL TIMDAY(TIME)			00003900 70.29
	ADDED	DO 100 I=1,500			00004000 70.29
	ADDED	XDOTA(I)=0.0			00004100 70.29
	ADDED	100 CONTINUE			00004200 70.29
	ADDED	CALL LNK1			00004300 70.29
	ADDED	IF(LEVEL.GT.1) GO TO 10			00004400 70.29
	ADDED	CALL LNK2			00004500 70.29
	ADDED	CALL OUTPUT			00004600 70.29
	ADDED	GO TO 10			00004700 70.29
	ADDED	END			00004800 70.29
	ADDED	SUBROUTINE LINT(X,Y,XIN,YOUT)			00004900 70.29
	ADDED	C			00005000 70.29
	ADDED	C	LINEAR INTERPOLATION ROUTINE		00005100 70.29
	ADDED	C	X= ARRAY OF X VALUES		00005200 70.29
	ADDED	C	Y= ARRAY OF Y VALUES		00005300 70.29
	ADDED	C	XIN= INPUT VALUE OF X		00005400 70.29
	ADDED	C	YOUT=INTERPOLATED Y VALUE CORRESPONDING TO XIN		00005500 70.29
	ADDED	C			00005600 70.29
	ADDED	C	*** WARNING- CHECK THAT XIN DOES NOT FALL OUTSIDE		00005700 70.29
	ADDED	C	THE RANGE OF VALUES IN X BEFORE ENTERING THIS		00005800 70.29
	ADDED	C	ROUTINE ***		00005900 70.29
	ADDED	C			00006000 70.29
	ADDED	C	DIMENSION X(I), Y(I)		00006100 70.29
	ADDED	C	I=1		00006200 70.29
	ADDED	C	100 CONTINUE		00006300 70.29
	ADDED	C	IF(XIN-X(I)) 130,120,110		00006400 70.29
	ADDED	C	110 CONTINUE		00006500 70.29
	ADDED	C	I=I+1		00006600 70.29
	ADDED	C	GO TO 100		00006700 70.29
	ADDED	C	120 CONTINUE		00006800 70.29
	ADDED	C	YOUT=Y(I)		00006900 70.29
	ADDED	C	GO TO 150		00007000 70.29
	ADDED	C	130 CONTINUE		00007100 70.29
	ADDED	C	YOUT=Y(I-1)+(XIN-X(I-1))*(Y(I)-Y(I-1))/(X(I)-X(I-1))		00007200 70.29
	ADDED	C	150 CONTINUE		00007300 70.29
	ADDED	C	RETURN		00007400 70.29
	ADDED	C	END		00007500 70.29
	ADDED	C	SUBROUTINE LNK1		00007600 70.29
	ADDED	C	EXTERNAL RNAT, VNAT, RHGLT, VHGLT, V4P3ET, RH20T, VH20T		00007700 70.29
	ADDED	C	EXTERNAL RARBT, VARBT		00007800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	REAL*8	DATE		
ADDED	COMMON /MUFCON/			
ADDED	1 A(3),	CUERR,	CONSIS(3,600), GC,	00007900 70.29
ADDED	2 IBCON(600),	IBRAN(850),	IFLUID, IOPT(10),	00008000 70.29
ADDED	3 ITEMP,	ITYPE(600),	JBRPT(600), LABEL(20,3),	00008100 70.29
ADDED	4 LEVEL,	MBRAN(850),	NBCON(250), NBRAN,	00008200 70.29
ADDED	5 NBRPTS,	NNMAX,	NPTS(150), PBRPT(250),	00008300 70.29
ADDED	6 QBR(150),	QERR,	RHO(600), TBULK(500),	00008400 70.29
ADDED	7 TOLERR,	VISC(600),	XDOTA(500)	00008500 70.29
ADDED	COMMON /MUFCON/	INOUT(100),	NDUMBP, LOOP	00008600 70.29
ADDED	COMMON /PUNT/	MNEM,MNODES, DATE		00008700 70.29
ADDED	COMMON /PUNT/	TIME		00008800 70.29
ADDED	COMMON /PQCHAR/			00008900 70.29
ADDED	1 PCHAR(11,50),	PCMAX(50),	QCHAR(11,50),	00009000 70.29
ADDED	2 QCMAX(50)			00009100 70.29
ADDED	COMMON /PQCHAR/	PCMIN(50),	QCMIN(50)	00009200 70.29
ADDED	COMMON /LICOM/			00009300 70.29
ADDED	1 ALPHA(600),	INODE(1200),	JNODE(1200), MEMNO(1200),	00009400 70.29
ADDED	2 NMEN,	NPLANE(600),	P(500), PHI(600),	00009500 70.29
ADDED	3 Q(600),	RADLEN(600),	XYZ(500,3), IEND(150,2),	00009600 70.29
ADDED	4 NENDS(2)			00009700 70.29
ADDED	LEVEL=0			00009800 70.29
ADDED	C	INITIALIZE NODE PRESSURE AND MEMBER FLOW RATE		00009900 70.29
ADDED	C	ARRAYS. P(IZ).LI.O INDICATES PRESSURE AT NODE		00010000 70.29
ADDED	C	IZ IS NOT FIXED.		00010100 70.29
ADDED	DO 155 IZ=1,500			00010200 70.29
ADDED	P(IZ)=-1.0			00010300 70.29
ADDED	Q(IZ)=0.0			00010400 70.29
ADDED	155 CONTINUE			00010500 70.29
ADDED	C	READ INPUT DATA		00010600 70.29
ADDED	CALL INPUT			00010700 70.29
ADDED	C	SORT CONNECTIVITY DATA INTO ASCENDING ORDER		00010800 70.29
ADDED	CALL SORT(3,NMEN,JNODE,INODE,MEMNO)			00010900 70.29
ADDED	CALL SORT(3,NMEN,INODE,JNODE,MEMNO)			00011000 70.29
ADDED	C	COMPUTE K-FACTORS, EQUIVALENT LENGTHS,		00011100 70.29
ADDED	C	FLUID DENSITY AND VISCOSITY,		00011200 70.29
ADDED	C	AND PRINT OUT MEMBER CHARACTERISTICS.		00011300 70.29
ADDED	GO TO(210,220,230,250,260), IFLUID			00011400 70.29
ADDED	210 CONTINUE			00011500 70.29
ADDED	CALL FORK(RNAT,VNAT)			00011600 70.29
ADDED				00011700 70.29
ADDED				00011800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
ADDED	GO TO 270			00011900 70.29
ADDED	220 CONTINUE			00012000 70.29
ADDED	CALL FORK(RHGLT,VHGLT)			00012100 70.29
ADDED	GO TO 270			00012200 70.29
ADDED	230 CONTINUE			00012300 70.29
ADDED	CALL FORK(R4P3ET,V4P3ET)			00012400 70.29
ADDED	GO TO 270			00012500 70.29
ADDED	250 CONTINUE			00012600 70.29
ADDED	CALL FORK(RH20T,VH20T)			00012700 70.29
ADDED	GO TO 270			00012800 70.29
ADDED	260 CONTINUE			00012900 70.29
ADDED	CALL FORK(RARBT,VARBT)			00013000 70.29
ADDED	270 CONTINUE			00013100 70.29
ADDED	C	TRACE BRANCHES, SET UP BRANCH CONNECTIVITY		00013200 70.29
ADDED	C	AND CHECK CONSTRAINTS.		00013300 70.29
ADDED	CALL NETWRK			00013400 70.29
ADDED	RETURN			00013500 70.29
ADDED	END			00013600 70.29
ADDED	SUBROUTINE RESIST(MEM,Q,INIT)			00013700 70.29
ADDED	FLOW RESISTANCE SUBROUTINE			00013800 70.29
ADDED	COMMON /MUFCON/			00013900 70.29
ADDED	1 A(3), COERR, CONSIS(3,600), GC,			00014000 70.29
ADDED	2 IBCON(600), IFLUID, IOPT(10),			00014100 70.29
ADDED	3 ITEMP, JBRPT(600), LABEL(20,3),			00014200 70.29
ADDED	4 LEVEL, MBRAN(850), NBRAN,			00014300 70.29
ADDED	5 NBRPTS, NNMAX, NPTS(150), PBRPT(250),			00014400 70.29
ADDED	6 QBR(150), QERR, RHO(600), TBULK(500),			00014500 70.29
ADDED	7 TOLERR, VISC(600), XDOTA(500)			00014600 70.29
ADDED	COMMON /MUFCON/ INOUT(100), NINOUT, NDUMBP, LOOP			00014700 70.29
ADDED	COMMON /PQCHAR/			00014800 70.29
ADDED	1 PCHAR(11,50), PCMAX(50), QCHAR(11,50), QCMAX(50)			00014900 70.29
ADDED	COMMON /PQCHAR/ PCMIN(50), QCMIN(50)			00015000 70.29
ADDED	DIMENSION ICONST(3,600)			00015100 70.29
ADDED	EQUIVALENCE (ICONST(1,1), CONSTS(1,1))			00015200 70.29
ADDED	IF(INIT.EQ.1) QB=(QCMIN(IT)+QCMAX(IT))/2.0			00015300 70.29
ADDED	QB=ABS(Q)			00015400 70.29
ADDED	TOLABS=1.0			00015500 70.29
ADDED	IF(QB.LT.TOLABS) QB=TOLABS			00015600 70.29
ADDED	GC=32.17			00015700 70.29
ADDED	IT=ITYPE(MEM)			00015800 70.29

NEW VOL=SER=007208

DRC UPDATE

OLD VOL=SER=004783

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDL
	ADDED	DIN=CONSTS(1, MEM)		00015900 70.29
	ADDED	IF(IT.LT.100000000) GO TO 100		00016000 70.29
	ADDED	C	FIXED PRESSURE DROP	00016100 70.29
	ADDED	RESIST=CONSTS(2, MEM)/QB		00016200 70.29
	ADDED	GO TO 500		00016300 70.29
	ADDED	100 CONTINUE		00016400 70.29
	ADDED	IT=MOD(IT, 100000000)		00016500 70.29
	ADDED	IF(IT.LT.10000) GO TO 200		00016600 70.29
	ADDED	150 CONTINUE		00016700 70.29
	ADDED	C	COMPONENT	00016800 70.29
	ADDED	IT=IT/10000		00016900 70.29
	ADDED	IF(INIT.EQ.1) QB=(QCMIN(IT)+QCMAX(IT))/2.0		00017000 70.29
	ADDED	RESIST=PTABLE(IT, QB)/QB		00017100 70.29
	ADDED	GO TO 500		00017200 70.29
	ADDED	200 CONTINUE		00017300 70.29
	ADDED	ELOVRD=CONSTS(2, MEM)		00017400 70.29
	ADDED	RE=4.2441317E-3*QB/(VISC(MEM)*DIN)		00017500 70.29
	ADDED	IF(INIT.EQ.2) GO TO 220		00017600 70.29
	ADDED	RE=4000.0		00017700 70.29
	ADDED	QB=RE*VISC(MEM)*DIN/4.2441317E-3		00017800 70.29
	ADDED	220 CONTINUE		00017900 70.29
	ADDED	IF(IT-99) 250, 280, 350		00018000 70.29
	ADDED	250 CONTINUE		00018100 70.29
	ADDED	IF(IT-2) 280, 260, 270		00018200 70.29
	ADDED	260 CONTINUE		00018300 70.29
	ADDED	C	BEND	00018400 70.29
	ADDED	ELOVRD=ELOVRD*RE**0.032		00018500 70.29
	ADDED	GO TO 280		00018600 70.29
	ADDED	270 CONTINUE		00018700 70.29
	ADDED	C	MODIFY EQUIVALENT LENGTH IF RE IS LESS THAN 1000	00018800 70.29
	ADDED	IF(RE.LT.1000.0) ELOVRD=ELOVRD/1000.0		00018900 70.29
	ADDED	280 CONTINUE		00019000 70.29
	ADDED	ITRANS=0		00019100 70.29
	ADDED	C	TEST FOR FLOW REGIME	00019200 70.29
	ADDED	IF(RE.GT.2100) GO TO 290		00019300 70.29
	ADDED	C	LAMINAR FLOW	00019400 70.29
	ADDED	FRICT=64.0/RE		00019500 70.29
	ADDED	GO TO 340		00019600 70.29
	ADDED	290 CONTINUE		00019700 70.29
	ADDED	IF(RE.GE.4000.0) GO TO 300		00019800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

D SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
	ADDED C	TRANSITION REGION - SET FLAG		00019900 70.29
	ADDED	ITRANS=1		00020000 70.29
	ADDED	SAVRE=RE		00020100 70.29
	ADDED	RE=4000.0		00020200 70.29
	ADDED	300 CONTINUE		00020300 70.29
	ADDED C	TURBULENT FLOW - EVALUATE COLEBROOK EXPRESSION		00020400 70.29
	ADDED C	FOR FRICTION FACTOR		00020500 70.29
	ADDED	FRICT=0.1		00020600 70.29
	ADDED C	RUFF=DIN/CONSTS(3, MEM)		00020700 70.29
	ADDED	RUFF=1.0E+6		00020800 70.29
	ADDED	TERM=4.0*ALOG10(RUFF)+2.28		00020900 70.29
	ADDED	DO 310 I=1,10		00021000 70.29
	ADDED	SFRICT=FRICT		00021100 70.29
	ADDED	FRICT=4.0/(TERM-4.0*ALOG10(1.0+9.33*RUFF/(RE*SQRT(FRICT))))**2		00021200 70.29
	ADDED	IF(ABS(FRICT-SFRICT)/FRICT.LE.0.01) GO TO 320		00021300 70.29
	ADDED	310 CONTINUE		00021400 70.29
	ADDED	320 CONTINUE		00021500 70.29
	ADDED	IF(ITRANS.EQ.0) GO TO 340		00021600 70.29
	ADDED C	INTERPOLATE FOR TRANSITION FRICTION FACTOR		00021700 70.29
	ADDED	FRICT={ALOG10(SAVRE)-3.32222}*(FRICT-.03048)/0.27984 + 0.03048		00021800 70.29
	ADDED	340 CONTINUE		00021900 70.29
	ADDED C	CALCULATE RESISTANCE FOR EQUIVALENT LENGTH TYPE MEMBERS		00022000 70.29
	ADDED	RESIST=9.00637E-6*FRICT*ELOVRD*QB/(RHO(MEM)*GC*DIN**4)		00022100 70.29
	ADDED	GO TO 500		00022200 70.29
	ADDED	350 CONTINUE		00022300 70.29
	ADDED	AK=CONSTS(2, MEM)		00022400 70.29
	ADDED C	MEMBERS WITH 'K' FACTOR		00022500 70.29
	ADDED	IT=IT/100		00022600 70.29
	ADDED	IF(IT.GT.13) GO TO 400		00022700 70.29
	ADDED C	BRANCH-OFF MEMBER		00022800 70.29
	ADDED	IF(IT.GT.6) GO TO 360		00022900 70.29
	ADDED	RESIST=BRLOSS(MEM, QB, INIT, IT)		00023000 70.29
	ADDED	GO TO 500		00023100 70.29
	ADDED	360 CONTINUE		00023200 70.29
	ADDED	IB=ICONST(3, MEM)/1000000		00023300 70.29
	ADDED	IF(IB.LE.0) GO TO 416		00023400 70.29
	ADDED	QBF=ABS(QBR(IB))		00023500 70.29
	ADDED	IEXP=MOD(ICONST(3, MEM), 1000000)/100000		00023600 70.29
	ADDED	DIN=MOD(ICONST(3, MEM), 100000)		00023700 70.29
	ADDED			00023800 70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DDI
	ADDED	DIN=DIN/10.0**IEXP		00023900 70.29
	ADDED	IF(INIT.EQ.1) QBF=VISC(MEM)*DIN/1.06103E-6		00024000 70.29
	ADDED	QB=QBF**2/QB		00024100 70.29
	ADDED	GO TO 416		00024200 70.29
	ADDED	400 CONTINUE		00024300 70.29
	ADDED	IF(11.NE.25) GO TO 415		00024400 70.29
	ADDED	AK=1.0/SQRT(ORFICE(CONSTS(3, MEM), RE))		00024500 70.29
	ADDED	DIN=CONSTS(2, MEM)		00024600 70.29
	ADDED	GO TO 420		00024700 70.29
	ADDED	415 CONTINUE		00024800 70.29
	ADDED	IF(11.GE.99) GO TO 420		00024900 70.29
	ADDED	416 CONTINUE		00025000 70.29
	ADDED	C	CORRECT 'K' FOR REYNOLDS NO.	00025100 70.29
	ADDED	IF(RE.GE.2000.0) GO TO 420		00025200 70.29
	ADDED	IF(RE.GT.100.0) GO TO 418		00025300 70.29
	ADDED	AK=1.5*AK		00025400 70.29
	ADDED	GO TO 420		00025500 70.29
	ADDED	418 CONTINUE		00025600 70.29
	ADDED	AK=1.3*AK		00025700 70.29
	ADDED	420 CONTINUE		00025800 70.29
	ADDED	C	CALCULATE RESISTANCE	00025900 70.29
	ADDED	RESIST=9.006336E-6*AK*QB / (GC*RHO(MEM)*DIN**4)		00026000 70.29
	ADDED	500 RETURN		00026100 70.29
	ADDED	END		00026200 70.29
	ADDED	FUNCTION PTABLE(INDEX,XQ)		00026300 70.29
	ADDED	COMMON /PQCHAR/		00026400 70.29
	ADDED	1 PQCHAR(11,50), PCMAX(50), QCHAR(11,50),		00026500 70.29
	ADDED	2 QCMAX(50)		00026600 70.29
	ADDED	COMMON /PQCHAR/		00026700 70.29
	ADDED	IF(XQ.LT.QCMAX(INDEX)) GO TO 20		00026800 70.29
	ADDED	PTABLE=PCMAX(INDEX)		00026900 70.29
	ADDED	RETURN		00027000 70.29
	ADDED	20 CONTINUE		00027100 70.29
	ADDED	IF(XQ.GT.QCMIN(INDEX)) GO TO 50		00027200 70.29
	ADDED	PTABLE=PCMIN(INDEX)		00027300 70.29
	ADDED	RETURN		00027400 70.29
	ADDED	50 CONTINUE		00027500 70.29
	ADDED	CALL LINT(QCHAR(1,INDEX),PCHAR(1,INDEX),XQ,PQTIDUM)		00027600 70.29
	ADDED	PTABLE=PQTIDUM		00027700 70.29
	ADDED	RETURN		00027800 70.29

OLD VOL=SER=004783		DRC UPDATE		NEW VOL=SER=007208	
OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN		YY.DD
	ADDED	END		00027900	70.29
	ADDED	FUNCTION QTABLE(IT,DP)		00028000	70.29
	ADDED	COMMON /PQCHAR/		00028100	70.29
	ADDED	1 PQCHAR(11,50), PCMAX(50), QCHAR(11,50), QCMA(50)		00028200	70.29
	ADDED	COMMON /PQCHAR/		00028300	70.29
	ADDED	IF(DP.LI.PCMAX(IT)) GO TO 100		00028400	70.29
	ADDED	QTABLE=QCMAX(IT)		00028500	70.29
	ADDED	RETURN		00028600	70.29
	ADDED	100 CONTINUE		00028700	70.29
	ADDED	IF(DP.GT.PCMIN(IT)) GO TO 200		00028800	70.29
	ADDED	QTABLE=QCMIN(IT)		00028900	70.29
	ADDED	RETURN		00029000	70.29
	ADDED	200 CONTINUE		00029100	70.29
	ADDED	CALL INT4(PCCHAR(1,IT),QCHAR(1,IT),DP,QDUM)		00029200	70.29
	ADDED	QTABLE=QDUM		00029300	70.29
	ADDED	RETURN		00029400	70.29
	ADDED	END		00029500	70.29
	ADDED	FUNCTION ORFCE(RATIN,REIN)		00029600	70.29
	ADDED	DIMENSION		00029700	70.29
	ADDED	1 COR20(28), COR30(28), COR40(28),		00029800	70.29
	ADDED	2 COR50(28), COR60(28), COR65(28),		00029900	70.29
	ADDED	3 COR70(28), COR75(28), COR80(28),		00030000	70.29
	ADDED	4 CORF(28,9), C(5), DRAT(9),		00030100	70.29
	ADDED	5 DR(5), RORF(28)		00030200	70.29
	ADDED	DATA DRAT / 0.20, 0.30, 0.40, 0.50, 0.60, 0.65, 0.70, 0.75, 0.80/		00030300	70.29
	ADDED	DATA RORF / 0.60206, 0.77815, 0.90309, 1.00000, 1.30103,		00030400	70.29
	ADDED	1 1.60206, 1.77815, 1.90309, 2.00000, 2.30103,		00030500	70.29
	ADDED	2 2.60206, 2.77815, 2.90309, 3.00000, 3.30103,		00030600	70.29
	ADDED	3 3.47712, 3.50515, 3.60206, 3.77815, 3.90309,		00030700	70.29
	ADDED	4 4.00000, 4.30103, 4.60206, 4.77815, 4.90309,		00030800	70.29
	ADDED	5 5.00000, 5.30103, 0.00000 /		00030900	70.29
020	ADDED	DATA COR20 / 0.328, 0.395, 0.441, 0.482, 0.580, 0.646, 0.677,		00031000	70.29
030	ADDED	1 0.687, 0.698, 0.708, 0.703, 0.687, 0.677, 0.667,		00031100	70.29
040	ADDED	2 0.636, 0.626, 0.624, 0.618, 0.616, 0.614, 0.613,		00031200	70.29
	ADDED	3 0.611, 0.611, 0.611, 0.611, 0.611, 0.611, 0.000 /		00031300	70.29
070	ADDED	DATA COR30 / 0.337, 0.406, 0.453, 0.495, 0.596, 0.664, 0.696,		00031400	70.29
080	ADDED	1 0.706, 0.717, 0.733, 0.727, 0.717, 0.706, 0.696,		00031500	70.29
090	ADDED	2 0.664, 0.651, 0.650, 0.642, 0.639, 0.637, 0.636,		00031600	70.29
	ADDED	3 0.632, 0.632, 0.632, 0.632, 0.632, 0.632, 0.000 /		00031700	70.29
120	ADDED	DATA COR40 / 0.351, 0.423, 0.472, 0.516, 0.626, 0.702, 0.735,		00031800	70.29
130	ADDED	1 0.746, 0.757, 0.779, 0.774, 0.768, 0.752, 0.746,			

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DDJ
140	ADDED	2	0.708, 0.692, 0.689, 0.681, 0.675, 0.673, 0.672,	00031900 70.29
	ADDED	3	0.666, 0.666, 0.666, 0.666, 0.666, 0.666, 0.000 /	00032000 70.29
010	ADDED	DATA COR50 /		00032100 70.29
020	ADDED	1	0.826, 0.837, 0.860, 0.860, 0.854, 0.843, 0.831,	00032200 70.29
030	ADDED	2	0.797, 0.774, 0.771, 0.762, 0.745, 0.739, 0.734,	00032300 70.29
	ADDED	3	0.726, 0.722, 0.721, 0.721, 0.721, 0.721, 0.000 /	00032400 70.29
060	ADDED	DATA COR60 /		00032500 70.29
070	ADDED	1	0.934, 0.959, 0.996, 1.009, 1.002, 0.996, 0.984,	00032600 70.29
080	ADDED	2	0.940, 0.909, 0.903, 0.884, 0.853, 0.845, 0.839,	00032700 70.29
	ADDED	3	0.826, 0.816, 0.812, 0.811, 0.811, 0.811, 0.000 /	00032800 70.29
110	ADDED	DATA COR65 /		00032900 70.29
120	ADDED	1	1.028, 1.061, 1.107, 1.126, 1.133, 1.126, 1.120,	00033000 70.29
130	ADDED	2	1.081, 1.028, 1.015, 0.989, 0.931, 0.918, 0.911,	00033100 70.29
	ADDED	3	0.893, 0.880, 0.875, 0.874, 0.872, 0.872, 0.000 /	00033200 70.29
010	ADDED	DATA COR70 /		00033300 70.29
020	ADDED	1	1.135, 1.176, 1.251, 1.278, 1.285, 1.285, 1.278,	00033400 70.29
030	ADDED	2	1.244, 1.183, 1.162, 1.107, 1.025, 0.999, 0.993,	00033500 70.29
	ADDED	3	0.969, 0.953, 0.949, 0.945, 0.945, 0.945, 0.000 /	00033600 70.29
060	ADDED	DATA COR75 /		00033700 70.29
070	ADDED	1	1.298, 1.349, 1.466, 1.525, 1.540, 1.543, 1.540,	00033800 70.29
080	ADDED	2	1.496, 1.422, 1.408, 1.342, 1.195, 1.131, 1.120,	00033900 70.29
	ADDED	3	1.097, 1.078, 1.071, 1.066, 1.063, 1.060, 0.000 /	00034000 70.29
110	ADDED	DATA COR80 /		00034100 70.29
120	ADDED	1	1.534, 1.613, 1.795, 1.897, 1.929, 1.945, 1.953,	00034200 70.29
130	ADDED	2	1.945, 1.834, 1.739, 1.557, 1.399, 1.336, 1.289,	00034300 70.29
	ADDED	3	1.257, 1.235, 1.225, 1.221, 1.216, 1.208, 0.000 /	00034400 70.29
	ADDED	EQUIVALENCE		00034500 70.29
	ADDED	1	(COR20(1),CORF(1,1)), (COR30(1),CORF(1,2)),	00034600 70.29
	ADDED	2	(COR40(1),CORF(1,3)), (COR50(1),CORF(1,4)),	00034700 70.29
	ADDED	3	(COR60(1),CORF(1,5)), (COR65(1),CORF(1,6)),	00034800 70.29
	ADDED	4	(COR70(1),CORF(1,7)), (COR75(1),CORF(1,8)),	00034900 70.29
	ADDED		(COR80(1),CORF(1,9))	00035000 70.29
	ADDED	RE=ALOG10(ABS(REIN))		00035100 70.29
	ADDED	RE=AMIN1(AMAX1(RE,0.60206),5.30103)		00035200 70.29
	ADDED	RATIO=AMIN1(AMAX1(RATIN,0.20),0.80)		00035300 70.29
	ADDED	DO 100 I=1,9		00035400 70.29
	ADDED	IF(RATIO-DRAT(I)) 120,110,100		00035500 70.29
	ADDED	100 CONTINUE		00035600 70.29
	ADDED	110 CONTINUE		00035700 70.29
	ADDED	I=I		00035800 70.29
	ADDED	CALL INT4(RORF,CORF(1,I),RE,ANS)		00035900 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

D SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
	ADDED	ORFICE=ANS		00035900 70.29
	ADDED	RETURN		00036000 70.29
	ADDED	120 CONTINUE		00036100 70.29
	ADDED	I1=MAX0(I-2,1)		00036200 70.29
	ADDED	I2=MIN0(I+1,9)		00036300 70.29
	ADDED	DO 200 I=11,12		00036400 70.29
	ADDED	INDEX=I-11+1		00036500 70.29
	ADDED	DR(INDEX)=DRAT(I)		00036600 70.29
	ADDED	CALL INT4(RORF,CORF(1,1),RE,C(INDEX))		00036700 70.29
	ADDED	200 CONTINUE		00036800 70.29
	ADDED	DR(INDEX+1)=0.0		00036900 70.29
	ADDED	C(INDEX+1)=0.0		00037000 70.29
	ADDED	CALL INT4(DR,C,RATIO,ANS)		00037100 70.29
	ADDED	ORFICE=ANS		00037200 70.29
	ADDED	RETURN		00037300 70.29
	ADDED	END		00037400 70.29
	ADDED	FUNCTION BRLOSS(MEM,QBRAN,INIT,IT)		00037500 70.29
	ADDED	COMMON /MUFCON/		00037600 70.29
	ADDED	1 A(3), CUERR, CONSTS(3,600), GC, IFLUID, IOPT(10),		00037700 70.29
	ADDED	2 IBCON(600), IBRAN(850),		00037800 70.29
	ADDED	3 ITEMP, ITYPE(600), JBRPT(600), LABEL(20,3),		00037900 70.29
	ADDED	4 LEVEL, MBRAN(850), NBCON(250), NBRAN,		00038000 70.29
	ADDED	5 NBRPTS, NNMAX, NPTS(150), PBRPT(250),		00038100 70.29
	ADDED	6 QBR(150), QERR, RHO(600), TBULK(500),		00038200 70.29
	ADDED	7 TOLERR, VISC(600), XDOTA(500)		00038300 70.29
	ADDED	COMMON /MUFCON/ INOUT(100), NDUMBP, LOOP		00038400 70.29
	ADDED	DIMENSION BKELBO(7,3), BKFHI(9,3), BKFL0(9,3),		00038500 70.29
	ADDED	1 VRELBO(7), VRF(9)		00038600 70.29
	ADDED	DIMENSION ICONST(3,600)		00038700 70.29
	ADDED	EQUIVALENCE ICONST(1,1), CONSTS(1,1)		00038800 70.29
	ADDED	DATA BKELBO/ 0.30, .303, 0.31, 0.33, 0.53, 1.00, 0.0,		00038900 70.29
	ADDED	1 0.21, 0.22, 0.23, 0.27, 0.41, 0.70, 0.0,		00039000 70.29
	ADDED	2 0.14, 0.15, 0.17, 0.21, 0.41, 0.53, 0.0 /,		00039100 70.29
	ADDED	3 VRELBO/ 0.10, 0.20, 0.30, 0.50, 1.00, 1.10, 0.0 /		00039200 70.29
	ADDED	DATA BKFHI/ 1.00, 0.85, 0.73, 0.60, 0.50, 0.53, 1.05, 2.00, 0.0,		00039300 70.29
	ADDED	1 1.00, 0.85, 0.73, 0.70, 0.80, 0.90, 1.30, 2.20, 0.0,		00039400 70.29
	ADDED	2 1.00, 1.02, 1.10, 1.30, 2.00, 2.30, 4.00, 6.00, 0.0/		00039500 70.29
	ADDED	DATA BKFL0/ 1.00, 0.80, 0.68, 0.50, 0.40, 0.43, 0.93, 1.40, 0.0,		00039600 70.29
	ADDED	1 1.00, 0.80, 0.68, 0.60, 0.65, 0.75, 1.05, 2.00, 0.0,		00039700 70.29
	ADDED	2 1.00, 1.01, 1.03, 1.20, 1.70, 2.05, 3.20, 4.80, 0.0/		00039800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	DATA VRF / 0.10, 0.20, 0.30, 0.50, 0.80, 1.00, 1.30, 2.00, 0.0/			00039900 70.29
ADDED	DATA CONV/19.6349 /			00040000 70.29
ADDED	DBRAN=CONSTS(1, MEM)			00040100 70.29
ADDED	IB=ICONST(3, MEM)/1000000			00040200 70.29
ADDED	IF(1B.GT.0) GO TO 100			00040300 70.29
ADDED	BRLUSS=1.08076E-6*QBRAN/(GC*RHO( MEM )*DBRAN**4)			00040400 70.29
ADDED	RETURN			00040500 70.29
ADDED	100 CONTINUE			00040600 70.29
ADDED	QMAIN=ABS(QBR(1B))			00040700 70.29
ADDED	IEXP=MOD(ICONST(3, MEM), 1000000)/100000			00040800 70.29
ADDED	DMAIN=MOD(ICONST(3, MEM), 100000)			00040900 70.29
ADDED	DMAIN=DMAIN/10.0**IEXP			00041000 70.29
ADDED	IF(1INIT.EQ.1) QMAIN=VISC(MEM)*DMAIN/1.06103E-6			00041100 70.29
ADDED	VBRAN=QBRAN/(RHO( MEM )*CONV*DBRAN**2)			00041200 70.29
ADDED	VMAIN=QMAIN/(RHC( MEM )*CONV*DMAIN**2)			00041300 70.29
ADDED	VRATIO=VBRAN/VMAIN			00041400 70.29
ADDED	IF(1T.GT.3) GO TO 300			00041500 70.29
ADDED	IF(VRATIO.GT.0.10) GO TO 200			00041600 70.29
ADDED	BK=1.0			00041700 70.29
ADDED	GO TO 400			00041800 70.29
ADDED	200 CONTINUE			00041900 70.29
ADDED	IF(VRATIO.GT.2.0) VRATIO=2.0			00042000 70.29
ADDED	DRATIO=DBRAN/DMAIN			00042100 70.29
ADDED	IF(DRATIO.GT.0.33333) GO TO 250			00042200 70.29
ADDED	CALL INT4(VRF, BKFHI(1, IT), VRATIO, BK)			00042300 70.29
ADDED	GO TO 400			00042400 70.29
ADDED	250 CONTINUE			00042500 70.29
ADDED	IF(DRATIO.LT.1.0) GO TO 260			00042600 70.29
ADDED	CALL INT4(VRF, BKFLO(1, IT), VRATIO, BK)			00042700 70.29
ADDED	GO TO 400			00042800 70.29
ADDED	260 CONTINUE			00042900 70.29
ADDED	CALL INT4(VRF, BKFHI(1, IT), VRATIO, BKH)			00043000 70.29
ADDED	CALL INT4(VRF, BKFLO(1, IT), VRATIO, BKL)			00043100 70.29
ADDED	BK=BKH - 1.5*(DRATIO-0.33333)*(BKH -BKL )			00043200 70.29
ADDED	GO TO 400			00043300 70.29
ADDED	300 CONTINUE			00043400 70.29
ADDED	IF(VRATIO.LT.0.10) VRATIO=0.10			00043500 70.29
ADDED	IF(VRATIO.GT.1.10) VRATIO=1.10			00043600 70.29
ADDED	CALL INT4(VRELBO, BKELBO(1, IT-3), VRATIO, BK)			00043700 70.29
ADDED	400 CONTINUE			00043800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	ADDED	BRLOSS=RHO(MEM)*((BK-1.0)*VMMAIN**2+VBRAN**2)/(9273.6*QBRAN)	00043900	70.29
ADDED	ADDED	IF(BRLOSS.LT.0.0) BRLOSS=0.0	00044000	70.29
ADDED	ADDED	RETURN	00044100	70.29
ADDED	ADDED	END	00044200	70.29
ADDED	ADDED	SUBROUTINE SKIP	00044300	70.29
ADDED	ADDED	DATA IEND/4HEND /	00044400	70.29
ADDED	ADDED	100 CONTINUE	00044500	70.29
ADDED	ADDED	READ(5,1000) ID	00044600	70.29
ADDED	ADDED	1000 FORMAT(A4)	00044700	70.29
ADDED	ADDED	IF(ID.NE.IEND) GO TO 100	00044800	70.29
ADDED	ADDED	RETURN	00044900	70.29
ADDED	ADDED	END	00045000	70.29
ADDED	ADDED	SUBROUTINE INPUT	00045100	70.29
ADDED	ADDED	REAL*8 DATE	00045200	70.29
ADDED	ADDED	COMMON /MUFCON/	00045300	70.29
ADDED	ADDED	1 A(3), COERR, CONSIS(3,600), GC,	00045400	70.29
ADDED	ADDED	2 IBCON(600), IFLUID, IOPT(10),	00045500	70.29
ADDED	ADDED	3 ITEMP, JBRPT(600), LABEL(20,3),	00045600	70.29
ADDED	ADDED	4 LEVEL, MBRAN(850), NBRAN,	00045700	70.29
ADDED	ADDED	5 NBRPTS, NNMAX, NPTS(150), PBRPT(250),	00045800	70.29
ADDED	ADDED	6 QBR(150), QERR, RHO(600), TBULK(500),	00045900	70.29
ADDED	ADDED	7 TOLERR, VISC(600), XDOTA(500)	00046000	70.29
ADDED	ADDED	COMMON /MUFCON/ INOUT(100), NDUMBP, LOOP	00046100	70.29
ADDED	ADDED	COMMON /LICOM/	00046200	70.29
ADDED	ADDED	1 ALPHA(600), INODE(1200), JNODE(1200), MEMNO(1200),	00046300	70.29
ADDED	ADDED	2 NMEM, NPLANE(600), P(500), PHI(600),	00046400	70.29
ADDED	ADDED	3 Q(600), RADLEN(600), XYZ(500,3), IEND(150,2),	00046500	70.29
ADDED	ADDED	4 NENDS(2)	00046600	70.29
ADDED	ADDED	COMMON /INCOM/	00046700	70.29
ADDED	ADDED	1 DOUT(600), DOKCVL(600), D2(600), EPSLON(600),	00046800	70.29
ADDED	ADDED	2 THICK(600)	00046900	70.29
ADDED	ADDED	COMMON /PQCHAR/	00047000	70.29
ADDED	ADDED	1 PCHAR(11,50), PCMAX(50), QCHAR(11,50),	00047100	70.29
ADDED	ADDED	2 QCMAX(50)	00047200	70.29
ADDED	ADDED	COMMON /PQCHAR/	00047300	70.29
ADDED	ADDED	COMMON /FARB/ FRHO(10), FVISC(10), FTEMP(10)	00047400	70.29
ADDED	ADDED	COMMON /PUNT/ MMEM,MNODES, DATE	00047500	70.29
ADDED	ADDED	COMMON /PUNT/ TIME	00047600	70.29
ADDED	ADDED	DIMENSION ICARD(15), NT(12), DATA(10)	00047700	70.29
ADDED	ADDED	DIMENSION CARD(20)	00047800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
ADDED	EQUIVALENCE (LIMIT,IOPT(1)), (INFT,IOPT(2))			00047900 70.29
ADDED	DATA ICARD/2HCP, 2HCQ, 2HEN, 2HFD, 2HFT, 2HFV, 2HI, 2HL, 2HM,			00048000 70.29
ADDED	1 2HN, 2HP, 2HT /			00048100 70.29
ADDED	DATA IPUMP/4HPUMP/, ICOMP/4HCOMP/			00048200 70.29
ADDED	NENDS(1)=1			00048300 70.29
ADDED	IEND(1,1)=1			00048400 70.29
ADDED	NCARD=1			00048500 70.29
ADDED	NLABEL=0			00048600 70.29
ADDED	NMEM=0			00048700 70.29
ADDED	5 CONTINUE			00048800 70.29
ADDED	IF(MOD(NCARD,30).NE.1) GO TO 6			00048900 70.29
ADDED	WRITE(6,800) DATE, TIME			00049000 70.29
ADDED	800 FORMAT(1H1//1H0,39(1H*),28H MUFAN CARD INPUT LISTING,19(1H*),			00049100 70.29
ADDED	1 2X,A8, 6H TIME, A4//7X,4HCARD,44X,			00049200 70.29
ADDED	2 13H CARD COLUMNS/7X,4HSEQ.,10X,9(1H0),10(1H1),10(1H2),			00049300 70.29
ADDED	3 10(1H3),10(1H4),10(1H5),10(1H6),10(1H7),1H8/,7X,4H NO.,			00049400 70.29
ADDED	4 10X,8(10H1234567890)//			00049500 70.29
ADDED	6 CONTINUE			00049600 70.29
ADDED	IF(NCARD.GE.2) WRITE(6,700) NCARD,ID,(CARD(1),I=1,20)			00049700 70.29
ADDED	700 FORMAT(7X,14,10X,A2,19A4,A2)			00049800 70.29
ADDED	NCARD=NCARD+1			00049900 70.29
ADDED	READ(5,900) ID,(CARD(1),I=1,20)			00050000 70.29
ADDED	900 FORMAT(A2,19A4,A2)			00050100 70.29
ADDED	DO 8 I=1,12			00050200 70.29
ADDED	IF(ICARD(1).EQ.ID) GO TO(10,10,30,40,50,60,70,80,90,100,110,120),100050300			00050300 70.29
ADDED	8 CONTINUE			00050400 70.29
ADDED	WRITE(6,999)			00050500 70.29
ADDED	999 FORMAT(1H0/1H,100(1H*)/1H0,33H** THE ABOVE CARD HAS AN ILLEGAL,			00050600 70.29
ADDED	1 54H CARD TYPE SYMBOL STARTING IN COLUMN 1 - CASE BYPASSED,			00050700 70.29
ADDED	2 9X,4H **/1H0,100(1H*)			00050800 70.29
ADDED	CALL SKIP			00050900 70.29
ADDED	LEVEL=10			00051000 70.29
ADDED	RETURN			00051100 70.29
ADDED	10 CONTINUE			00051200 70.29
ADDED	C ** COMPONENT PRESSURE DROP OR FLOW RATE CARD **			00051300 70.29
ADDED	READ(99,1000) KIND,NO, (DATA(K),K=1,10)			00051400 70.29
ADDED	1000 FORMAT(3X,A4,I3,10F7.0)			00051500 70.29
ADDED	DATA(11)=0.0			00051600 70.29
ADDED	IBASE=0			00051700 70.29
ADDED	SGN=1.0			00051800 70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

D SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	IF(KIND.EQ.IPUMP) GO TO 11			00051900 70.29
ADDED	IF(KIND.EQ.ICOMP) GO TO 12			00052000 70.29
ADDED	WRITE(6,1999) NCARD,KIND			00052100 70.29
ADDED	1999 FORMAT(1H1//////////1X,7H** THE ,14,21HTH DATA CARD FOR THIS,			00052200 70.29
ADDED	1 36H CASE HAS AN ILLEGAL COMPONENT TYPE,,A4, 6H -CASE,			00052300 70.29
ADDED	2 12H BYPASSED **)			00052400 70.29
ADDED	ERROR=1002			00052500 70.29
ADDED	RETURN			00052600 70.29
ADDED	11 CONTINUE			00052700 70.29
ADDED	SGN=-1.0			00052800 70.29
ADDED	IBASE=41			00052900 70.29
ADDED	12 CONTINUE			00053000 70.29
ADDED	INDEX=IBASE+NO			00053100 70.29
ADDED	IF(INDEX.LE.50.AND.INDEX.GT.0) GO TO 14			00053200 70.29
ADDED	WRITE(6,2999) NCARD,NO			00053300 70.29
ADDED	2999 FORMAT(1H1//////////1X,7H** THE ,14, 26HTH DATA CARD FOR THIS CASE,00053400 70.29			00053500 70.29
ADDED	1 32H HAS AN ILLEGAL PUMP OR COMP NO.,14,15H -CASE BYPASSED,			00053600 70.29
ADDED	2 3H **)			00053700 70.29
ADDED	ERROR=1002			00053800 70.29
ADDED	RETURN			00053900 70.29
ADDED	14 CONTINUE			00054000 70.29
ADDED	CMAX=DATA(1)			00054100 70.29
ADDED	IF(1.EQ.1) CMAX=SGN*CMAX			00054200 70.29
ADDED	DO 20 J=1,10			00054300 70.29
ADDED	GO TO (16,18),1			00054400 70.29
ADDED	16 CONTINUE			00054500 70.29
ADDED	IF(DATA(J).EQ.0.0.AND.J.GT.1) GO TO 17			00054600 70.29
ADDED	CMAX=AMAX1(SGN*DATA(J),CMAX)			00054700 70.29
ADDED	17 CONTINUE			00054800 70.29
ADDED	PCHAR(J,INDEX)=DATA(J)			00054900 70.29
ADDED	GO TO 20			00055000 70.29
ADDED	18 CONTINUE			00055100 70.29
ADDED	QCHAR(J,INDEX)=DATA(J)			00055200 70.29
ADDED	QCMAX(INDEX)=AMAX1(DATA(J),CMAX)			00055300 70.29
ADDED	CMAX=QCMAX(INDEX)			00055400 70.29
ADDED	20 CONTINUE			00055500 70.29
ADDED	GO TO(24,26), 1			00055600 70.29
ADDED	24 CONTINUE			00055700 70.29
ADDED	PCMIN(INDEX)=DATA(1)			00055800 70.29
ADDED	PCMAX(INDEX)=SGN*CMAX			00055900 70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

D SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	GO TO 5			00055900 70.29
ADDED	26 CONTINUE			00056000 70.29
ADDED	QCIN(INDEX)=DATA(1)			00056100 70.29
ADDED	GO TO 5			00056200 70.29
ADDED	30 CONTINUE			00056300 70.29
ADDED	C	** END OF CASE CARD **		00056400 70.29
ADDED	RETURN			00056500 70.29
ADDED	40 CONTINUE			00056600 70.29
ADDED	C	** FLUID DENSITY CARD **		00056700 70.29
ADDED	READ(99,3000) (FRHO(K),K=1,9)			00056800 70.29
ADDED	3000 FORMAT(2X,9F8.0)			00056900 70.29
ADDED	IRFARB=1			00057000 70.29
ADDED	GO TO 5			00057100 70.29
ADDED	50 CONTINUE			00057200 70.29
ADDED	C	** FLUID TEMPERATURE CARD **		00057300 70.29
ADDED	READ(99,3000) (FTEMP(K),K=1,9)			00057400 70.29
ADDED	FTEMP(10)=0.0			00057500 70.29
ADDED	ITFARB=1			00057600 70.29
ADDED	GO TO 5			00057700 70.29
ADDED	60 CONTINUE			00057800 70.29
ADDED	C	** FLUID VISCOSITY CARD **		00057900 70.29
ADDED	READ(99,3000) (FVISC(K),K=1,9)			00058000 70.29
ADDED	FVISC(10)=0.0			00058100 70.29
ADDED	IVFARB=1			00058200 70.29
ADDED	GO TO 5			00058300 70.29
ADDED	70 CONTINUE			00058400 70.29
ADDED	C	** INPUT NODE NUMBERS CARD **		00058500 70.29
ADDED	READ(99,7000) (IEND(K,1),K=2,16)			00058600 70.29
ADDED	7000 FORMAT(5X,15I5)			00058700 70.29
ADDED	GO TO 5			00058800 70.29
ADDED	80 CONTINUE			00058900 70.29
ADDED	C	** LABEL CARD **		00059000 70.29
ADDED	NLABEL=NLABEL+1			00059100 70.29
ADDED	IF(NLABEL.GT.3) GO TO 5			00059200 70.29
ADDED	READ(99,8000) (LABEL(K,NLABEL),K=1,19)			00059300 70.29
ADDED	8000 FORMAT(1X,A3,19A4)			00059400 70.29
ADDED	GO TO 5			00059500 70.29
ADDED	90 CONTINUE			00059600 70.29
ADDED	C	** MEMBER CARD **		00059700 70.29
ADDED	NMEM=NMEM+2			00059800 70.29

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OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	NM=NMEM/2			00059900 70.29
ADDED	IF(NMEM.LE.1200) GO TO 95			00060000 70.29
ADDED	WRITE(6,9999) NCARD			00060100 70.29
ADDED	9999 FORMAT(1H1////////1X,7H** THE ,14,21H1H DATA CARD FOR THIS,			00060200 70.29
ADDED	1 33H CASE DEFINES THE 1201ST MEMBER. /1X,9HONLY 1200,			00060300 70.29
ADDED	2 39H MEMBERS ARE ALLOWED - CASE BYPASSED ** )			00060400 70.29
ADDED	RETURN			00060500 70.29
ADDED	95 CONTINUE			00060600 70.29
ADDED	READ(99,9000) INODE(NMEM-1), JNODE(NMEM-1), NPLANE(NM),			00060700 70.29
ADDED	1 ALPHA(NM), RADLEN(NM), DOUT(NM), THICK(NM),			00060800 70.29
ADDED	2 PHI(NM), ITYPE(NM), DOKCVL(NM), D2(NM), Q(NM),			00060900 70.29
ADDED	3 EPSLON(NM)			00061000 70.29
ADDED	9000 FORMAT(2X,I3,2X,I3,1X,I1,1X,F3.0,1X,F7.0,1X,F5.0,1X,F4.0,			00061100 70.29
ADDED	1 I10,1X,F6.0,1X,F6.0,1X,F6.0,1X,F6.0)			00061200 70.29
ADDED	IF(INFT.GT.0) RADLEN(NM)=RADLEN(NM)/12.0			00061300 70.29
ADDED	MEMNO(NMEM-1)=NM			00061400 70.29
ADDED	MEMNO(NMEM)= -NM			00061500 70.29
ADDED	INODE(NMEM)=JNODE(NMEM-1)			00061600 70.29
ADDED	JNODE(NMEM)=INODE(NMEM-1)			00061700 70.29
ADDED	GO TO 5			00061800 70.29
ADDED	100 CONTINUE			00061900 70.29
ADDED	C ** NODE CARD **			00062000 70.29
ADDED	READ(99,10000) NODE,NODE2			00062100 70.29
ADDED	10000 FORMAT(2X,I3,1X,I3)			00062200 70.29
ADDED	IF(NODE.GT.0.AND.NODE.LE.500) GO TO 105			00062300 70.29
ADDED	102 CONTINUE			00062400 70.29
ADDED	WRITE(6,10999) NCARD,NODE			00062500 70.29
ADDED	10999 FORMAT(1H1////////1X,7H** THE ,14,25H1H DATA CARD FOR THIS CASE,			00062600 70.29
ADDED	1 25H HAS AN ILLEGAL NODE NO.,14,15H -CASE BYPASSED )			00062700 70.29
ADDED	IERROR=1010			00062800 70.29
ADDED	RETURN			00062900 70.29
ADDED	105 CONTINUE			00063000 70.29
ADDED	READ(99,10001) XYZ(NODE,1), XYZ(NODE,2), XYZ(NODE,3), TBULK(NODE)			00063100 70.29
ADDED	10001 FORMAT(2X,I3,1X,I3,1X,4F8.0)			00063200 70.29
ADDED	XDATA(NODE)=XYZ(NODE,1)*A(1)+XYZ(NODE,2)*A(2)+XYZ(NODE,3)*A(3)			00063300 70.29
ADDED	IF(NODE2) 102,108,106			00063400 70.29
ADDED	106 CONTINUE			00063500 70.29
ADDED	DO 107 1=NODE,NODE2			00063600 70.29
ADDED	XDATA(1)=XDATA(NODE)			00063700 70.29
ADDED	107 CONTINUE			00063800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	108 CONTINUE		00063900 70.29
	ADDED	GO TO 5		00064000 70.29
	ADDED	110 CONTINUE		00064100 70.29
	ADDED	C	** PRESSURE CONSTRAINT CARD **	00064200 70.29
	ADDED	READ(99,11000) NODE, PRESS		00064300 70.29
	ADDED	11000 FORMAT(2X,13,3X,F6.0)		00064400 70.29
	ADDED	IF(NODE.GT.0.AND.NODE.LE.500) GO TO 115		00064500 70.29
	ADDED	WRITE(6,10999) NCARD,NODE		00064600 70.29
	ADDED	IFERROR=1011		00064700 70.29
	ADDED	RETURN		00064800 70.29
	ADDED	115 CONTINUE		00064900 70.29
	ADDED	P(NODE)=PRESS		00065000 70.29
	ADDED	GO TO 5		00065100 70.29
	ADDED	120 CONTINUE		00065200 70.29
	ADDED	C	** TEMPERATURE CARD **	00065300 70.29
	ADDED	IFLAG=1		00065400 70.29
	ADDED	READ(99,12000) (NT(K),K=1,12), TEMP		00065500 70.29
	ADDED	12000 FORMAT(1X,12(1X,14),4X,F8.0)		00065600 70.29
	ADDED	DO 190 J=1,12		00065700 70.29
	ADDED	IF(NT(J).GT.500) GO TO 200		00065800 70.29
	ADDED	IF(NT(J)) 200,130,140		00065900 70.29
	ADDED	130 CONTINUE		00066000 70.29
	ADDED	IF(J.EQ.1) GO TO 200		00066100 70.29
	ADDED	IFLAG=0		00066200 70.29
	ADDED	GO TO 190		00066300 70.29
	ADDED	140 CONTINUE		00066400 70.29
	ADDED	IF(IFLAG.EQ.0) GO TO 150		00066500 70.29
	ADDED	LNZ=NT(J)		00066600 70.29
	ADDED	TBULK(LNZ)=TEMP		00066700 70.29
	ADDED	GO TO 190		00066800 70.29
	ADDED	150 CONTINUE		00066900 70.29
	ADDED	IF(LNZ.LE.NT(J)) GO TO 160		00067000 70.29
	ADDED	LNZ=LNZ		00067100 70.29
	ADDED	LNZ=NT(J)		00067200 70.29
	ADDED	GO TO 170		00067300 70.29
	ADDED	160 CONTINUE		00067400 70.29
	ADDED	LNZ=NT(J)		00067500 70.29
	ADDED	170 CONTINUE		00067600 70.29
	ADDED	DO 180 K=LNZ,NNZ		00067700 70.29
	ADDED	TBULK(K)=TEMP		00067800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	180 CONTINUE			00067900 70.29
ADDED	IFLAG=1			00068000 70.29
ADDED	LNZ=NT(J)			00068100 70.29
ADDED	190 CONTINUE			00068200 70.29
ADDED	GO TO 5			00068300 70.29
ADDED	200 CONTINUE			00068400 70.29
ADDED	K=J			00068500 70.29
ADDED	WRITE(6,10999) NCARD,NT(K)			00068600 70.29
ADDED	IERROR=1012			00068700 70.29
ADDED	RETURN			00068800 70.29
ADDED	END			00068900 70.29
ADDED	SUBROUTINE FORK(/RXXXI/,/VXXXI/)			00069000 70.29
ADDED	REAL*8 TYPES, TYPES1, TYPES2			00069100 70.29
ADDED	REAL*8 TYP0UT			00069200 70.29
ADDED	REAL*8 DATE			00069300 70.29
ADDED	COMMON /MUFCON/			00069400 70.29
ADDED	U A(3), CUERR, CONSTS(3,600), GC,			00069500 70.29
ADDED	2 IBCON(600), IBRAN(850), IFLUID, IOPT(10),			00069600 70.29
ADDED	3 ITEMP, ITYPE(600), JBRPT(600), TITLE(20,3),			00069700 70.29
ADDED	4 LEVEL, MBRAN(850), NBCON(250), NBRAN,			00069800 70.29
ADDED	5 NBRPTS, NNMAX, NPTS(150), PBRPT(250),			00069900 70.29
ADDED	6 QBR(150), QERR, RHQ(600), TBULK(500),			00070000 70.29
ADDED	7 TOLERR, VISC(600), XDOTA(500)			00070100 70.29
ADDED	COMMON /MUFCON/ INOUT(100), NDUMB, LOOP			00070200 70.29
ADDED	COMMON /LICOM/			00070300 70.29
ADDED	1 ALPHA(600), INODE(1200), JNODE(1200), MEMND(1200),			00070400 70.29
ADDED	2 NMEN, NPLANE(600), P(500), PHI(600),			00070500 70.29
ADDED	3 Q(600), RADLEN(600), XYZ(500,3), IEND(150,2),			00070600 70.29
ADDED	4 NENDS(2)			00070700 70.29
ADDED	COMMON /INCOM/			00070800 70.29
ADDED	1 DOUT(600), DOKCVL(600), D2(600), EPSLON(600),			00070900 70.29
ADDED	2 THICK(600)			00071000 70.29
ADDED	COMMON /PUNT/ MMEN,MNODES, DATE			00071100 70.29
ADDED	COMMON /PUNT/ TIME			00071200 70.29
ADDED	COMMON /INCOM/ LABEL(8,600)			00071300 70.29
ADDED	COMMON /FORKLD/			00071400 70.29
ADDED	1 ALOUT(4), ODOUT(4), THKOUT(4), ROUT(4),			00071500 70.29
ADDED	2 ANGOUT(4), D2OUT(4), RUFOUT(4), ELROUT(4),			00071600 70.29
ADDED	3 AKOUT(4)			00071700 70.29
ADDED	DIMENSION OUT(4,9)			00071800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ MESSAGE

FILENAME=MUFAN

DECKNAME=MUFAN

YY.DDI

ADDED	DIMENSION	IFORM(12,11)							00071900	70.29
ADDED	DIMENSION	TYPES(4,45),	TYPES1(4,13),	TYPES2(4,27),					00072000	70.29
ADDED	1	TYPES3(8,5),	MOUT(2,4),	ITENS(10),					00072100	70.29
ADDED	2	TYPOUT(4,4)							00072200	70.29
ADDED	DIMENSION	RTABLE(11),	XTABLE(11)						00072300	70.29
ADDED	DIMENSION	BENDC(21),	ROVRD(21),	ANGLC(14),					00072400	70.29
ADDED	1	THETA(14),	AKFACT(10)						00072500	70.29
ADDED	DIMENSION	ICONST(3,600)							00072600	70.29
ADDED	DIMENSION	LOUT(8,4)							00072700	70.29
ADDED	EQUIVALENCE	(ICONST(1,1), CONSTS(1,1))							00072800	70.29
ADDED	EQUIVALENCE	(OUT(1,1), ALOUT(1))							00072900	70.29
ADDED	EQUIVALENCE	(TYPES1(1,1), TYPES(1,1)), (TYPES2(1,1), TYPES(1,14)), (ANUM, NUM)							00073000	70.29
ADDED	1	(TYPES3(1,1), TYPES(1,41)), (ANUM, NUM)							00073100	70.29
ADDED	DATA RTABLE/	1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 7.5, 10.0,							00073200	70.29
ADDED	1	0.0/							00073300	70.29
ADDED	DATA XTABLE/	3.0, 1.8, 1.25, 1.20, 1.25, 1.70, 2.13, 2.70, 3.50,							00073400	70.29
ADDED	1	4.82, 0.0 /							00073500	70.29
ADDED	DATA ROVRD/	0.00, 0.20, 0.60, 0.80, 1.00, 1.60, 2.00, 3.00,							00073600	70.29
ADDED	1	3.50, 4.00, 4.60, 5.00, 6.00, 7.00, 8.00, 10.0,							00073700	70.29
ADDED	2	12.0, 14.0, 16.0, 18.0, 0.00 /							00073800	70.29
ADDED	DATA BENDC/	0.86, 0.85, 0.70, 0.45, 0.34, 0.26, .195, 0.16,							00073900	70.29
ADDED	1	0.15, .153, 0.16, .175, 0.21, 0.24, .165, .313,							00074000	70.29
ADDED	2	0.35, .378, .396, 0.41, 0.00 /							00074100	70.29
ADDED	DATA THETA/	0.0, 15.0, 30.0, 45.0, 60.0, 75.0, 90.0, 105.,							00074200	70.29
ADDED	1	120., 135., 150., 165., 180., 0.00 /							00074300	70.29
ADDED	DATA ANGLC/	0.00, 0.22, 0.43, 0.61, 0.76, 0.90, 1.00, 1.08,							00074400	70.29
ADDED	1	1.15, 1.22, 1.28, 1.33, 1.38, 0.00 /							00074500	70.29
ADDED	DATA AKFACT /	3.00, 0.15, 0.10, 0.06, 0.50, 1.50, 3.00 /							00074600	70.29
ADDED	DATA STARS/-1.0E+20/								00074700	70.29
ADDED	DATA TYPES1/								00074800	70.29
ADDED	1	STRAIGHT PIPE						TUBING BEND	00074900	70.29
ADDED	2							ELBOW	00075000	70.29
ADDED	3	STANDARD 45 DEG.						LONG 90 DEG.	00075100	70.29
ADDED	4	ELBOW						BEND	00075200	70.29
ADDED	5	GATE VALVE						SWING CHECK	00075300	70.29
ADDED	6								00075400	70.29
ADDED	7	GLOBE VALVE						STANDARD TEE	00075500	70.29
ADDED	8	STRAIGHT THRU						THRU BRANCH	00075600	70.29
ADDED	9	EQUIVALENT L/D						INPUT BY USER	00075700	70.29
ADDED	DATA TYPES2/								00075800	70.29

OLD VOL=SER=004783

**DRC UPDATE**

NEW VOL=SER=007208

OLD SEQ MESSAGE

MESSAGE FILENAME=MUFAN

DECKNAME=MUFAN

DECKNAME=MUFAN

YY.DD

ADDED	1	' 45 DEG BRANCH	' , ' MAIN TO BRANCH	' , ' 60 DEG BRANCH	' ,	00075900	70.29
ADDED	2	' MAIN TO BRANCH	' , ' 90 DEG BRANCH	' , ' MAIN TO BRANCH	' ,	00076000	70.29
ADDED	3	' 45 DEG BRANCH	' , 'FROM 90 DEG BEND	' , ' 7 DEG BRANCH	' ,	00076100	70.29
ADDED	4	'FROM 90 DEG BEND	' , ' 15 DEG BRANCH	' , 'FROM 25 DEG BEND	' ,	00076200	70.29
ADDED	5	' 135 DEG BRANCH	' , ' MAIN TO BRANCH	' , ' 45 DEG BRANCH	' ,	00076300	70.29
ADDED	6	' THRU MAIN	' , ' 90 DEG BRANCH	' , ' THRU MAIN	' ,	00076400	70.29
ADDED	7	' 135 DEG BRANCH	' , ' THRU MAIN	' , ' 45 DEG BRANCH	' ,	00076500	70.29
ADDED	8	' BRANCH TO MAIN	' , ' 90 DEG BRANCH	' , ' BRANCH TO MAIN	' ,	00076600	70.29
ADDED	9	' 135 DEG BRANCH	' , ' BRANCH TO MAIN	' , ' TUBING BEND	' ,	00076700	70.29
ADDED	A	' ,	' ,	' ,	' ,	00076800	70.29
ADDED	B	' STANDARD 90 DEG	' , ' ELBOW	' , ' STANDARD 45 DEG	' ,	00076900	70.29
ADDED	C	' ELBOW	' , ' LONG 90 DEG	' , ' ELBOW	' ,	00077000	70.29
ADDED	D	' STANDARD TEE	' , ' THRU BRANCH	' , ' STANDARD TEE	' ,	00077100	70.29
ADDED	E	' STRAIGHT THRU	' , ' CLOSE RETURN	' , ' BEND	' ,	00077200	70.29
ADDED	F	' GRADUAL	' , ' CONTRACTION	' , ' GRADUAL	' ,	00077300	70.29
ADDED	G	' EXPANSION	' , ' SUDDEN	' , ' CONTRACTION	' ,	00077400	70.29
ADDED	H	' SUDDEN	' , ' EXPANSION	' , ' ORFICE	' ,	00077500	70.29
ADDED	I	' ,	' , ' NOZZLE	' , ' ,	' ,	00077600	70.29
ADDED	J	' K-FACTOR	' , ' INPUT BY USER	' /	' /	00077700	70.29
ADDED		DATA TYPES3/				00077800	70.29
ADDED	1	' COMPONENT XX	' , ' ,	' , ' PUMP XX	' ,	00077900	70.29
ADDED	2	' ,	' , ' FIXED PRESSURE	' , ' DROP	' ,	00078000	70.29
ADDED	3	' FREE PRESSURE	' , ' DROP	' , ' FIXED PRESSURE	' ,	00078100	70.29
ADDED	4	' RISE	' /			00078200	70.29
ADDED		DATA ITEMS/	Z4040F040, Z40F1F040, Z40F2F040, Z40F3F040, Z40F4F040, Z40F5F040, Z40F6F040, Z40F7F040, Z40F8F040, Z40F9F040/			00078300	70.29
ADDED	1	Z40F5F040, Z40F6F040, Z40F7F040, Z40F8F040, Z40F9F040/				00078400	70.29
ADDED		DATA IFORM/	48H(3X, 'LENGTH, FT.', 8X, 1H*, 0(6X, F8.3, 6X, 1H*)/3X, , 00078500			00078500	70.29
ADDED	1	48H*Q.D., IN. (01)', 5X, 1H*, 0(7X, F7.3, 6X, 1H*)/3X, , 00078600				00078600	70.29
ADDED	2	48H*WALL THICKNESS, IN *, 0(7X, F7.4, 6X, 1H*)/3X, , 00078700				00078700	70.29
ADDED	3	48H*RADIUS, FT.', 8X, 1H*, 0(6X, F8.3, 6X, 1H*)/3X, , 00078800				00078800	70.29
ADDED	4	48H*ANGLE, DEG.', 8X, 1H*, 0(8X, F5.1, 7X, 1H*)/3X, , 00078900				00078900	70.29
ADDED	5	48H*D2, IN.', 12X, 1H*, 0(7X, F7.3, 6X, 1H*)/3X, , 00079000				00079000	70.29
ADDED	6	48H*ROUGHNESS, IN.', 5X, 1H*, 0(7X, E7.2, 6X, 1H*)/3X, , 00079100				00079100	70.29
ADDED	7	48H*EQUIV. L/D', 9X, 1H*, 0(7X, F7.3, 6X, 1H*)/3X, , 00079200				00079200	70.29
ADDED	8	48H*K-FAC TOR', 11X, 1H*, 0(7X, F7.3, 6X, 1H*)/3X, , 00079300				00079300	70.29
ADDED	9	48H*LABEL', 14X, 1H*, 0(2X, 4A4, 2X, 1H*)/				00079400	70.29
ADDED	A	48H22X, 1H*, 0(2X, 4A4, 2X, 1H*)}				00079500	70.29
ADDED		NEQMAX=12				00079600	70.29
ADDED		NM=NNMEM/2				00079700	70.29
ADDED		NPAGES=(NM-1)/8+1				00079800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	IPAGE=0		00079900 70.29
	ADDED	IO=0		00080000 70.29
	ADDED	ISET=3		00080100 70.29
	ADDED	DO 1500 N=1,NMEM		00080200 70.29
	ADDED	IF(MEMNO(N).LE.0) GO TO 1500		00080300 70.29
	ADDED	MEM=MEMNO(N)		00080400 70.29
	ADDED	C	COMPUTE AVERAGE BULK TEMP, DENSITY AND VISCOSITY	00080500 70.29
	ADDED	L=INODE(N)		00080600 70.29
	ADDED	J=JNODE(N)		00080700 70.29
	ADDED	TBAVG=0.5*(TBULK(L)+TBULK(J))		00080800 70.29
	ADDED	RHO(MEM)=RXXXT(TBAVG,ISTEP,IERR)		00080900 70.29
	ADDED	VISC(MEM)=VXXXT(TBAVG,ISTEP,IERR)		00081000 70.29
	ADDED	IO=IO+1		00081100 70.29
	ADDED	DO 20 L=1,8		00081200 70.29
	ADDED	LOUT(L,IO)=LABEL(L, MEM)		00081300 70.29
	ADDED	20 CONTINUE		00081400 70.29
	ADDED	MOUT(1,IO)=INODE(N)		00081500 70.29
	ADDED	MOUT(2,IO)=JNODE(N)		00081600 70.29
	ADDED	DIN=DOUT(MEM)-2.0*THICK(MEM)		00081700 70.29
	ADDED	DO 30 J=1,9		00081800 70.29
	ADDED	OUT(IO,J)=STARS		00081900 70.29
	ADDED	30 CONTINUE		00082000 70.29
	ADDED	IF(ITYPE(MEM)-100000000) 40,32,34		00082100 70.29
	ADDED	32 CONTINUE		00082200 70.29
	ADDED	CALL LDTYPE(TYPES(1,43),TYP0UT,IO)		00082300 70.29
	ADDED	CONSTS(2, MEM)=Q(MEM)		00082400 70.29
	ADDED	GO TO 1000		00082500 70.29
	ADDED	34 CONTINUE		00082600 70.29
	ADDED	IF(ITYPE(MEM).EQ.3000000000) GO TO 36		00082700 70.29
	ADDED	CONSTS(1, MEM)=DIN		00082800 70.29
	ADDED	DOOUT(IO)=DOUT(MEM)		00082900 70.29
	ADDED	THKOUT(IO)=THICK(MEM)		00083000 70.29
	ADDED	CALL LDTYPE(TYPES(1,44),TYP0UT,IO)		00083100 70.29
	ADDED	GO TO 1000		00083200 70.29
	ADDED	36 CONTINUE		00083300 70.29
	ADDED	CALL LDTYPE(TYPES(1,45),TYP0UT,IO)		00083400 70.29
	ADDED	CONSTS(2, MEM)=Q(MEM)		00083500 70.29
	ADDED	GO TO 1000		00083600 70.29
	ADDED	40 CONTINUE		00083700 70.29
	ADDED	IF(EPSLON(MEM).LE.0.0) EPSLON(MEM)=1.0E-7		00083800 70.29







OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	RETURN		00087900 70.29
	ADDED	130 CONTINUE		00088000 70.29
	ADDED	GO TO (140,180,190,200,210,220,230,240,250,260,270) ,IT		00088100 70.29
	ADDED	140 CONTINUE		00088200 70.29
	ADDED	C	TUBING BEND	00088300 70.29
	ADDED	RATIO=ABS(RADLEN(MEM))/DIN		00088400 70.29
	ADDED	IF(RATIO.GE.1.0) GO TO 150		00088500 70.29
	ADDED	WRITE(6,9002) INODE(N), JNODE(N)		00088600 70.29
	ADDED	IF(IT.EQ.98) GO TO 900		00088700 70.29
	ADDED	9002 FORMAT(1H1//////////1X,9H** MEMBER,2I4,21H HAS R/D LESS THAN 1,,		00088800 70.29
	ADDED	1 47H CANNOT COMPUTE EQUIV LENGTH - CASE BYPASSED ** )		00088900 70.29
	ADDED	RETURN		00089000 70.29
	ADDED	150 CONTINUE		00089100 70.29
	ADDED	IF(RATIO.GT.7.5) GO TO 160		00089200 70.29
	ADDED	CALL INT4(RTABLE,XTABLE,RATIO,X)		00089300 70.29
	ADDED	GO TO 170		00089400 70.29
	ADDED	160 CONTINUE		00089500 70.29
	ADDED	X=0.482*RATIO		00089600 70.29
	ADDED	170 CONTINUE		00089700 70.29
	ADDED	ELOVD=0.0202*X*PHI(MEM)**1.1		00089800 70.29
	ADDED	CONSTS(2,MEM)=ELOVD		00089900 70.29
	ADDED	ROUT(IO)=RADLEN(MEM)		00090000 70.29
	ADDED	ANGOUT(IO)=PHI(MEM)		00090100 70.29
	ADDED	ELOUT(IO)=ELOVD		00090200 70.29
	ADDED	GO TO 180		00090300 70.29
	ADDED	180 CONTINUE		00090400 70.29
	ADDED	C	STANDARD 90 DEG ELBOW	00090500 70.29
	ADDED	ANGOUT(IO)=PHI(MEM)		00090600 70.29
	ADDED	ELOUT(IO)=30.0		00090700 70.29
	ADDED	CONSTS(2,MEM)=30.0		00090800 70.29
	ADDED	GO TO 190		00090900 70.29
	ADDED	190 CONTINUE		00091000 70.29
	ADDED	C	STANDARD 45 DEG ELBOW	00091100 70.29
	ADDED	ANGOUT(IO)=PHI(MEM)		00091200 70.29
	ADDED	ELOUT(IO)=16.0		00091300 70.29
	ADDED	CONSTS(2,MEM)=16.0		00091400 70.29
	ADDED	GO TO 200		00091500 70.29
	ADDED	200 CONTINUE		00091600 70.29
	ADDED	C	LONG 90 DEG ELBOW	00091700 70.29
	ADDED	ANGOUT(IO)=PHI(MEM)		00091800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	ELOUT(IO)=20.0		00091900 70.29
	ADDED	CONSTS(2, MEM)=20.0		00092000 70.29
	ADDED	GO TO 1000		00092100 70.29
	ADDED	210 CONTINUE		00092200 70.29
	ADDED	C	CLOSE RETURN BEND	00092300 70.29
	ADDED	ANGOUT(IO)=PHI(MEM)		00092400 70.29
	ADDED	ELOUT(IO)=50.0		00092500 70.29
	ADDED	CONSTS(2, MEM)=50.0		00092600 70.29
	ADDED	GO TO 1000		00092700 70.29
	ADDED	220 CONTINUE		00092800 70.29
	ADDED	C	GATE VALVE	00092900 70.29
	ADDED	ELOUT(IO)=13.0		00093000 70.29
	ADDED	CONSTS(2, MEM)=13.0		00093100 70.29
	ADDED	GO TO 1000		00093200 70.29
	ADDED	230 CONTINUE		00093300 70.29
	ADDED	C	SWING CHECK	00093400 70.29
	ADDED	ELOUT(IO)=135.0		00093500 70.29
	ADDED	CONSTS(2, MEM)=135.0		00093600 70.29
	ADDED	GO TO 1000		00093700 70.29
	ADDED	240 CONTINUE		00093800 70.29
	ADDED	C	ANGLE VALVE	00093900 70.29
	ADDED	ELOUT(IO)=145.0		00094000 70.29
	ADDED	CONSTS(2, MEM)= 145.0		00094100 70.29
	ADDED	GO TO 1000		00094200 70.29
	ADDED	250 CONTINUE		00094300 70.29
	ADDED	C	GLOBE VALVE	00094400 70.29
	ADDED	ELOUT(IO)=340.0		00094500 70.29
	ADDED	CONSTS(2, MEM)=340.0		00094600 70.29
	ADDED	GO TO 1000		00094700 70.29
	ADDED	260 CONTINUE		00094800 70.29
	ADDED	C	STANDARD TEE - STRAIGHT THRU	00094900 70.29
	ADDED	ELOUT(IO)=10.0		00095000 70.29
	ADDED	CONSTS(2, MEM)= 10.0		00095100 70.29
	ADDED	GO TO 1000		00095200 70.29
	ADDED	270 CONTINUE		00095300 70.29
	ADDED	C	STANDARD TEE - THRU BRANCH	00095400 70.29
	ADDED	ELOUT(IO)=60.0		00095500 70.29
	ADDED	CONSTS(2, MEM)= 60.0		00095600 70.29
	ADDED	500 CONTINUE		00095700 70.29
	ADDED	C		00095800 70.29

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OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
	ADDED C	K-FACTORS		00095900 70.29
	ADDED C			00096000 70.29
	ADDED	IT=IT/100		00096100 70.29
	ADDED	IF(IT-99) 510,505,900		00096200 70.29
	ADDED	505 CONTINUE		00096300 70.29
	ADDED	AKOUT(IO)=DOKCVL(MEM)		00096400 70.29
	ADDED	CONSTS(2, MEM)=DOKCVL(MEM)		00096500 70.29
	ADDED	ODOUT(IO)=DOUT(MEM)		00096600 70.29
	ADDED	THKOUT(IO)=THICK(MEM)		00096700 70.29
	ADDED	CALL LDTYPE(TYPES2(1,27),TYP0UT,IO)		00096800 70.29
	ADDED	GO TO 1000		00096900 70.29
	ADDED	510 CONTINUE		00097000 70.29
	ADDED	CALL LDTYPE(TYPES2(1,IT),TYP0UT,IO)		00097100 70.29
	ADDED	ODOUT(IO)=DOUT(MEM)		00097200 70.29
	ADDED	THKOUT(IO)=THICK(MEM)		00097300 70.29
	ADDED	IF(IT.GT.13) GO TO 515		00097400 70.29
	ADDED	D2OUT(IO)=D2(MEM)		00097500 70.29
	ADDED	D2IN=D2(MEM)-2.0*THICK(MEM)		00097600 70.29
	ADDED	IEXP=ALOG10(D2IN)		00097700 70.29
	ADDED	IEXP=4-IEXP		00097800 70.29
	ADDED	IND2=D2IN*10.0*IEXP		00097900 70.29
	ADDED	ICONST(3, MEM)=IEXP*100000+IND2		00098000 70.29
	ADDED	IF(IT.LE.6) GO TO 1000		00098100 70.29
	ADDED	515 CONTINUE		00098200 70.29
	ADDED	NKMAX=26		00098300 70.29
	ADDED	IF(IT.LE.NKMAX) GO TO 520		00098400 70.29
	ADDED	WRITE(6,9001) INODE(N), JNODE(N)		00098500 70.29
	ADDED	STOP		00098600 70.29
	ADDED	520 CONTINUE		00098700 70.29
	ADDED	IT=IT-6		00098800 70.29
	ADDED	IF(IT-8) 530,540,560		00098900 70.29
	ADDED	530 CONTINUE		00099000 70.29
	ADDED	AKOUT(IO)=AKFACT(IT)		00099100 70.29
	ADDED	CONSTS(2, MEM)=AKFACT(IT)		00099200 70.29
	ADDED	GO TO 1000		00099300 70.29
	ADDED	540 CONTINUE		00099400 70.29
	ADDED C	TUBING BEND		00099500 70.29
	ADDED	ROUT(IO)=RADLEN(MEM)		00099600 70.29
	ADDED	ANGOUT(IO)=PHI(MEM)		00099700 70.29
	ADDED	IF(PHI(MEM).GT.0.0.AND.PHI(MEM).LE.180.0) GO TO 550		00099800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
ADDED	WRITE(6,9004) INUDE(N), JNODE(N), PHI(MEM)			00099900 70.29
ADDED	9004 FORMAT(1H1////////1X,107(1H*))//1H0,'ANGLE FOR TUBING BEND',14,			00100000 70.29
ADDED	1 2H -,13,'=',612.5,'-OUT OF LIMITS',//1H0,107(1H*))			00100100 70.29
ADDED	STOP			00100200 70.29
ADDED	550 CONTINUE			00100300 70.29
ADDED	RD=ABS(RADLEN(MEM)*12.0/DIN)			00100400 70.29
ADDED	IF(RD.GT.18.0) RD=18.0			00100500 70.29
ADDED	CALL INT4(ROVRD,BENDC,RD,BC)			00100600 70.29
ADDED	AC=1.0			00100700 70.29
ADDED	IF(PHI(MEM).NE.90.0) CALL INT4(THETA,ANGLC,PHI(MEM),AC)			00100800 70.29
ADDED	CONSTS(2,MEM)=AC*BC			00100900 70.29
ADDED	AKOUT(10)=CONSTS(2,MEM)			00101000 70.29
ADDED	GO TO 1000			00101100 70.29
ADDED	560 CONTINUE			00101200 70.29
ADDED	IT=IT-8			00101300 70.29
ADDED	GO TO(565,570,580,590,600,610,620,630,640,650,660,670), IT			00101400 70.29
ADDED	565 CONTINUE			00101500 70.29
ADDED	C STANDARD 90 DEG ELBOW			00101600 70.29
ADDED	CONSTS(2,MEM)=PICK(1,DIN)			00101700 70.29
ADDED	AKOUT(10)=CONSTS(2,MEM)			00101800 70.29
ADDED	GO TO 1000			00101900 70.29
ADDED	570 CONTINUE			00102000 70.29
ADDED	C STANDARD 45 DEGREE ELBOW			00102100 70.29
ADDED	CONSTS(2,MEM)=PICK(2,DIN)			00102200 70.29
ADDED	AKOUT(10)=CONSTS(2,MEM)			00102300 70.29
ADDED	GO TO 1000			00102400 70.29
ADDED	580 CONTINUE			00102500 70.29
ADDED	C LONG 90 DEGREE ELBOW			00102600 70.29
ADDED	CONSTS(2,MEM)=PICK(3,DIN)			00102700 70.29
ADDED	AKOUT(10)=CONSTS(2,MEM)			00102800 70.29
ADDED	GO TO 1000			00102900 70.29
ADDED	590 CONTINUE			00103000 70.29
ADDED	C STANDARD TEE - THRU BRANCH			00103100 70.29
ADDED	CONSTS(2,MEM)=PICK(4,DIN)			00103200 70.29
ADDED	AKOUT(10)=CONSTS(2,MEM)			00103300 70.29
ADDED	GO TO 1000			00103400 70.29
ADDED	600 CONTINUE			00103500 70.29
ADDED	C STANDARD TEE - THRU MAIN			00103600 70.29
ADDED	CONSTS(2,MEM)=PICK(5,DIN)			00103700 70.29
ADDED	AKOUT(10)=CONSTS(2,MEM)			00103800 70.29

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OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
	ADDED	GO TO 1000		00103900 70.29
	ADDED	610 CONTINUE		00104000 70.29
	ADDED	C	CLOSE RETURN BEND	00104100 70.29
	ADDED	CONSTS(2, MEM)=PICK(6, DIN)		00104200 70.29
	ADDED	AKOUT(IO)=CONSTS(2, MEM)		00104300 70.29
	ADDED	GO TO 1000		00104400 70.29
	ADDED	620 CONTINUE		00104500 70.29
	ADDED	C	GRADUAL CONTRACTION	00104600 70.29
	ADDED	D1=D2(MEM)		00104700 70.29
	ADDED	CONSTS(2, MEM)=GRCK(D1, DIN, RADLEN(MEM), ISTEP, IERR)		00104800 70.29
	ADDED	D2OUT(IO)=D2(MEM)		00104900 70.29
	ADDED	ALOUT(IO)=RADLEN(MEM)		00105000 70.29
	ADDED	CONSTS(1, MEM)=D2(MEM)		00105100 70.29
	ADDED	AKOUT(IO)=CONSTS(2, MEM)		00105200 70.29
	ADDED	IF(CONSTS(2, MEM).GT.0.0) GO TO 1000		00105300 70.29
	ADDED	IERR=1		00105400 70.29
	ADDED	RETURN		00105500 70.29
	ADDED	630 CONTINUE		00105600 70.29
	ADDED	C	GRADUAL EXPANSION	00105700 70.29
	ADDED	DB=D2(MEM)		00105800 70.29
	ADDED	CONSTS(2, MEM)=GREXK(DIN, DB, RADLEN(MEM), ISTEP, IERR)		00105900 70.29
	ADDED	D2OUT(IO)=D2(MEM)		00106000 70.29
	ADDED	ALOUT(IO)=RADLEN(MEM)		00106100 70.29
	ADDED	AKOUT(IO)=CONSTS(2, MEM)		00106200 70.29
	ADDED	IF(CONSTS(2, MEM).GT.0.0) GO TO 1000		00106300 70.29
	ADDED	IERR=2		00106400 70.29
	ADDED	RETURN		00106500 70.29
	ADDED	640 CONTINUE		00106600 70.29
	ADDED	C	SUDDEN CONTRACTION	00106700 70.29
	ADDED	DB=D2(MEM)		00106800 70.29
	ADDED	CONSTS(2, MEM)=SUSC(DB, DIN, ISTEP, IERR)		00106900 70.29
	ADDED	AKOUT(IO)=CONSTS(2, MEM)		00107000 70.29
	ADDED	D2OUT(IO)=D2(MEM)		00107100 70.29
	ADDED	CONSTS(1, MEM)=D2(MEM)		00107200 70.29
	ADDED	IF(CONSTS(2, MEM).GE.0.0) GO TO 1000		00107300 70.29
	ADDED	IERR=3		00107400 70.29
	ADDED	RETURN		00107500 70.29
	ADDED	650 CONTINUE		00107600 70.29
	ADDED	C	SUDDEN EXPANSION	00107700 70.29
	ADDED	DB=D2(MEM)		00107800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ MESSAGE

FILENAME=MUFAN

DECKNAME=MUFAN

YY.DDI

ADDED

CONSTS(2, MEM)=SUSX(DIN, DB, ISTEP, IERR)  
D2OUT(IO)=D2(MEM)

00107900

70.29

ADDED

00108000

70.29

ADDED

AKOUT(IO)=CONSTS(2, MEM)

00108100

70.29

ADDED

IF(CONSTS(2, MEM).GE.0.0) GO TO 1000

00108200

70.29

ADDED

IERR=4

00108300

70.29

ADDED

RETURN

00108400

70.29

ADDED

660 CONTINUE

00108500

70.29

ADDED

C

ORFICE

00108600

70.29

ADDED

CONSTS(3, MEM)=D2(MEM)/DIN

00108700

70.29

ADDED

CONSTS(2, MEM)=D2(MEM)

00108800

70.29

ADDED

D2OUT(IO)=D2(MEM)

00108900

70.29

ADDED

GO TO 680

00109000

70.29

ADDED

670 CONTINUE

00109100

70.29

ADDED

C

NOZZLE

00109200

70.29

ADDED

CONSTS(3, MEM)=D2(MEM)/DIN

00109300

70.29

ADDED

CONSTS(2, MEM)=D2(MEM)

00109400

70.29

ADDED

D2OUT(IO)=D2(MEM)

00109500

70.29

ADDED

680 CONTINUE

00109600

70.29

ADDED

IF(CONSTS(3, MEM).GT.0.0.AND.CONSTS(3, MEM).LE.0.80) GO TO 1000

00109700

70.29

ADDED

WRITE(6, 9003) INODE(N), JNODE(N)

00109800

70.29

ADDED

9003 FORMAT(1H1////////1X, 107(1H\*)/1H0, 16X, 'MEMBER ', 13, ' -', 13,

00109900

70.29

ADDED

1 ' IS A NOZZLE OR ORFICE WITH D2/D1=', G10.3, ' (OUT OF RANGE)'/

00110000

70.29

ADDED

2 1H0, 107(1H\*)

00110100

70.29

ADDED

STOP

00110200

70.29

ADDED

900 CONTINUE

00110300

70.29

ADDED

IT=IT/100

00110400

70.29

ADDED

IF(IT.GT.41) GO TO 920

00110500

70.29

ADDED

JT=IT/10

00110600

70.29

ADDED

KT=(IT-10\*JT)\*256

00110700

70.29

ADDED

NUM=ITENS(JT+1)+KT

00110800

70.29

ADDED

TYPES(4, 1)=ANUM

00110900

70.29

ADDED

CALL LDTYPE(TYPES3(1, 1), TYP0UT, IO)

00111000

70.29

ADDED

GO TO 1000

00111100

70.29

ADDED

920 CONTINUE

00111200

70.29

ADDED

IT=IT/100

00111300

70.29

ADDED

NUM=ITENS(1)+IT\*256

00111400

70.29

ADDED

TYPES3(3, 2)=ANUM

00111500

70.29

ADDED

CALL LDTYPE(TYPES3(1, 2), TYP0UT, IO)

00111600

70.29

ADDED

1000 CONTINUE

00111700

70.29

ADDED

GO TO(1120, 1120, 1100), ISET

00111800

70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
ADDED	1100 CONTINUE			00111900 70.29
ADDED	IPAGE=IPAGE+1			00112000 70.29
ADDED	WRITE(6,6000) DATE, TIME, IPAGE,NPAGES,TITLE			00112100 70.29
ADDED	6000 FORMAT(1H1//1H0,36(1H*), ' MUFAN MEMBER FLOW CHARACTERISTICS ** ',00112200 70.29			
ADDED	1 A8,2X,A4, ' ** PAGE',13, ' OF',13, ' *',1//((17X,19A4))			00112300 70.29
ADDED	ISEI=1			00112400 70.29
ADDED	1120 CONTINUE			00112500 70.29
ADDED	IF(N.GE.NMEM-1) GO TO 1150			00112600 70.29
ADDED	IF(10.LT.4) GO TO 1500			00112700 70.29
ADDED	1150 CONTINUE			00112800 70.29
ADDED	DO 1200 J=1,11			00112900 70.29
ADDED	IFORM(7,J)=IFORM(7,J)+10			00113000 70.29
ADDED	1200 CONTINUE			00113100 70.29
ADDED	WRITE(6,6001) ((MOUT(I,J),I=1,2),J=1,10)			00113200 70.29
ADDED	6001 FORMAT(1H0//3X, 'MEMBER',13X,1H*,4(6X,13, ' -',13,6X,1H*))			00113300 70.29
ADDED	WRITE(6,6002) ((TYP0UT(I,J),I=1,2),J=1,10)			00113400 70.29
ADDED	6002 FORMAT(3X,19(1H-),1H*,4('-----*'))/3X, 'TYPE',15X,			00113500 70.29
ADDED	1 1H*,4(2X,2A8,2X,1H*))			00113600 70.29
ADDED	WRITE(6,6003) ((TYP0UT(I,J),I=3,4),J=1,10)			00113700 70.29
ADDED	6003 FORMAT(22X,1H*,4(2X,2A8,2X,1H*))			00113800 70.29
ADDED	WRITE(6,IFORM) ((OUT(I,J),I=1,10),J=1,9),			00113900 70.29
ADDED	1 ((LOUT(K,L),K=1,4),L=1,10), ((LOUT(K1,L1),K1=5,8),L1=1,10)			00114000 70.29
ADDED	DO 1250 J=1,11			00114100 70.29
ADDED	IFORM(7,J)=IFORM(7,J)-10			00114200 70.29
ADDED	1250 CONTINUE			00114300 70.29
ADDED	IO=0			00114400 70.29
ADDED	ISEI=ISEI+1			00114500 70.29
ADDED	1500 CONTINUE			00114600 70.29
ADDED	RETURN			00114700 70.29
ADDED	END			00114800 70.29
ADDED	SUBROUTINE LDTYPE(TYPIN,TYP0UT,IO)			00114900 70.29
ADDED	REAL*8 TYPIN, TYP0UT			00115000 70.29
ADDED	DIMENSION TYPIN(1), TYP0UT(4,4)			00115100 70.29
ADDED	DO 100 I=1,4			00115200 70.29
ADDED	TYP0UT(I,IO)=TYPIN(I)			00115300 70.29
ADDED	100 CONTINUE			00115400 70.29
ADDED	RETURN			00115500 70.29
ADDED	END			00115600 70.29
ADDED	FUNCTION SUDD(X)			00115700 70.29
ADDED	DIMENSION RATABL(12), KEXP(12), KCONT(12)			00115800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
ADDED	REAL KEXP, KCONT			00115900 70.29
ADDED	DATA RATABLE / 0., 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, .7, .8, .9, 1., 0./			00116000 70.29
ADDED	DATA KEXP / 1., .82, .64, .5, .385, .27, .19, .12, .05, .02,			00116100 70.29
ADDED	1 .005, 0.0/			00116200 70.29
ADDED	DATA KCONT / .44, .42, .39, .35, .31, .26, .19, .12, .05, .02,			00116300 70.29
ADDED	1 .005, 0.0/			00116400 70.29
ADDED	ENTRY SUSX (D1, D2, ISTEP, IERR)			00116500 70.29
ADDED	IERR = 1			00116600 70.29
ADDED	RATIO = D1/D2			00116700 70.29
ADDED	IF( RATIO .LT. 0.0 .OR. RATIO .GT. 1.0) GO TO 10			00116800 70.29
ADDED	CALL INT4 ( RATABLE, KEXP, RATIO, ANS)			00116900 70.29
ADDED	SUSX = ANS			00117000 70.29
ADDED	RETURN			00117100 70.29
ADDED	ENTRY SUSX (D1, D2, ISTEP, IERR)			00117200 70.29
ADDED	IERR = 1			00117300 70.29
ADDED	RATIO = D1/D2			00117400 70.29
ADDED	IF( RATIO .LT. 0.0 .OR. RATIO .GT. 1.0) GO TO 10			00117500 70.29
ADDED	CALL INT4 ( RATABLE, KCONT, RATIO, ANS)			00117600 70.29
ADDED	SUSX = ANS			00117700 70.29
ADDED	RETURN			00117800 70.29
ADDED	10 CONTINUE			00117900 70.29
ADDED	C ERROR MESSAGE			00118000 70.29
ADDED	SUDD = -1.0			00118100 70.29
ADDED	RETURN			00118200 70.29
ADDED	END			00118300 70.29
ADDED	FUNCTION GREXK (D1, D2, ALONG, ISTEP, IERR)			00118400 70.29
ADDED	DIMENSION ZETAD(6), TABLK(15, 6), TABLRT(15), V(6)			00118500 70.29
ADDED	DATA ZETAD/ 15., 20., 30., 40., 60., 0.0 /			00118600 70.29
ADDED	DATA TABLRT			00118700 70.29
ADDED	1 1.9, 2.0, 2.25, 2.5, 3.0, 3.5, 4.0, 0.0/			00118800 70.29
ADDED	DATA TABLK			00118900 70.29
ADDED	1 .133, .147, .173, .193, .220, .233, .240, 0.0,			00119000 70.29
ADDED	2 .080, .107, .133, .160, .180, .210,			00119100 70.29
ADDED	3 .230, .253, .267, .295, .320, .350, .367, .370, 0.0,			00119200 70.29
ADDED	4 .087, .113, .176, .233, .300, .347,			00119300 70.29
ADDED	5 .383, .420, .447, .486, .509, .533, .543, .547, 0.0,			00119400 70.29
ADDED	6 .100, .147, .207, .280, .367, .440,			00119500 70.29
ADDED	7 .487, .527, .560, .601, .640, .667, .676, .680, 0.0,			00119600 70.29
ADDED	8 .133, .200, .267, .367, .467, .533,			00119700 70.29
ADDED	9 .600, .643, .683, .747, .783, .840, .867, .880, 0.0,			00119800 70.29





OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	7 .60, .56, .51, .50, .50, .50, .50, .50, .50, .00,	00123900	70.29
	ADDED	8	.97, .94, .92, .88, .85, .795, .755,	00124000 70.29
	ADDED	9 .72, .68, .62, .585, .565, .54, .52, .50, 0.,	00124100	70.29
	ADDED	A	.99, .97, .954, .93, .915, .88, .85,	00124200 70.29
	ADDED	B .82, .795, .745, .695, .645, .60, .55, .50, 0.0,	00124300	70.29
	ADDED	C	0., 0., 0., 0., 0., 0., 0., 0., 0.,	00124400 70.29
	ADDED	D 0., 0., 0., 0., 0., 0., 0.07	00124500	70.29
	ADDED	IERR = 1	00124600	70.29
	ADDED	DIFF = D2 - D1	00124700	70.29
	ADDED	RATIO = ALONG / D1	00124800	70.29
	ADDED	X = DIFF / 2.0	00124900	70.29
	ADDED	PHI = ATAN(X/ALONG) * (360.0 / ( 2.0*3.141592)) * 2.0	00125000	70.29
	ADDED	IF (PHI .GT. 180.0 .OR. PHI .LT. 2.0) GO TO 700	00125100	70.29
	ADDED	IF (RATIO .GT. 1.0 .OR. RATIO .LT. 0.02) GO TO 700	00125200	70.29
	ADDED	DO 10 J = 1, 7	00125300	70.29
	ADDED	CALL INT4 (PHITAB, TABLK(1,J), PHI, V(J))	00125400	70.29
	ADDED	10 CONTINUE	00125500	70.29
	ADDED	DO 15 I = 1,15	00125600	70.29
	ADDED	15 Z(I) = -Z(I)	00125700	70.29
	ADDED	19 CALL INT4 (TABLD1, V, RATIO, ANS)	00125800	70.29
	ADDED	DO 17 I = 1,16	00125900	70.29
	ADDED	17 Z(I) = -Z(I)	00126000	70.29
	ADDED	GRCK = ANS	00126100	70.29
	ADDED	20 RETURN	00126200	70.29
	ADDED	700 CONTINUE	00126300	70.29
	ADDED	GRCK = -1.0	00126400	70.29
	ADDED	RETURN	00126500	70.29
	ADDED	END	00126600	70.29
	ADDED	FUNCTION PICK(I,D)	00126700	70.29
	ADDED	DIMENSION YK(5,10), XD(5)	00126800	70.29
	ADDED	DATA YK / 3.82, 0.68, 0.58, 0.50, 0.0,	00126900	70.29
	ADDED	1 0.43, 0.36, 0.30, 0.26, 0.0 ,	00127000	70.29
	ADDED	2 0.55, 0.45, 0.38, 0.33, 0.0 ,	00127100	70.29
	ADDED	3 0.55, 0.45, 0.38, 0.33, 0.0 ,	00127200	70.29
	ADDED	4 1.70, 1.40, 1.20, 1.00, 0.0 ,	00127300	70.29
	ADDED	5 1.40, 1.20, 0.96, 0.80, 0.0/,	00127400	70.29
	ADDED	6 XD / 0.50, 1.00, 2.00, 4.00, 0.07	00127500	70.29
	ADDED	D1=D*12.0	00127600	70.29
	ADDED	NPICK=6	00127700	70.29
	ADDED	IF(1.LE.NPICK) GO TO 100	00127800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DDI
	ADDED	WRITE(6,9000) MEM		00127900 70.29
	ADDED	9000 FORMAT(1H1//////////1X,9H** MEMBER,14,		00128000 70.29
	ADDED	1 46H HAS AN ILLEGAL COMPONENT TYPE - CASE BYPASSED)		00128100 70.29
	ADDED	IERR=1		00128200 70.29
	ADDED	RETURN		00128300 70.29
	ADDED	100 CONTINUE		00128400 70.29
	ADDED	IF(DI-XD(1)) I20,I20,I10		00128500 70.29
	ADDED	110 CONTINUE		00128600 70.29
	ADDED	IF(DI-XD(6)) I30,I40,I40		00128700 70.29
	ADDED	120 CONTINUE		00128800 70.29
	ADDED	PICK=YK(1,I)		00128900 70.29
	ADDED	GO TO 150		00129000 70.29
	ADDED	130 CONTINUE		00129100 70.29
	ADDED	CALL LINT(XD,YK(1,I),DI,ANS)		00129200 70.29
	ADDED	PICK=ANS		00129300 70.29
	ADDED	GO TO 150		00129400 70.29
	ADDED	140 CONTINUE		00129500 70.29
	ADDED	PICK=YK(6,I)		00129600 70.29
	ADDED	150 CONTINUE		00129700 70.29
	ADDED	RETURN		00129800 70.29
	ADDED	END		00129900 70.29
	ADDED	SUBROUTINE NETWRK		00130000 70.29
	ADDED	COMMON /MUFCOM/		00130100 70.29
	ADDED	1 A(3),	CONSIS(3,600), GC,	00130200 70.29
	ADDED	2 IBCON(600),	IFLUID, IOPT(10),	00130300 70.29
	ADDED	3 ITEMP,	JBRPT(600), LABEL(20,3),	00130400 70.29
	ADDED	4 LEVEL,	NBRAN,	00130500 70.29
	ADDED	5 NBRPTS,	NPTS(150), PBRPT(250),	00130600 70.29
	ADDED	6 QBR(150),	RHO(600), TBULK(500),	00130700 70.29
	ADDED	7 TOLERR,	XDOTA(500)	00130800 70.29
	ADDED	COMMON /MUFCOM/	INOUT(100), NDUMBP, LOOP	00130900 70.29
	ADDED	COMMON /LICOM/		00131000 70.29
	ADDED	1 ALPHA(600),	JNODE(1200), MEMNO(1200),	00131100 70.29
	ADDED	2 NMEM,	NPLANE(600), P(500), PHI(600),	00131200 70.29
	ADDED	3 Q(600),	RADLEN(600), XYZ(500,3), IEND(150,2),	00131300 70.29
	ADDED	4 NENDS(2)		00131400 70.29
	ADDED	COMMON /ARCOM/		00131500 70.29
	ADDED	1	IFIND(500), IORDER(150), NCON(500),	00131600 70.29
	ADDED	2	NFIND(150)	00131700 70.29
	ADDED	COMMON /ARCOM/	IORDBP(100)	00131800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDL
ADDED	COMMON /PUNT/ MMEM, MNODES			00131900 70.29
ADDED	C WRITE(6,8001) (INODE(I), MEMNQ(I), JNODE(I), I=1,NMEM)			00132000 70.29
ADDED	C8001 FORMAT(1H1,5HINODE,2X,5HMEMNQ,2X,5HJNODE//((3X,13,4X,13,4X,13))			00132100 70.29
ADDED	DO 20 I=1,500			00132200 70.29
ADDED	NCON(I)=0			00132300 70.29
ADDED	20 CONTINUE			00132400 70.29
ADDED	INDEX=INODE(I)			00132500 70.29
ADDED	NCON(INDEX)=1			00132600 70.29
ADDED	NNODES=1			00132700 70.29
ADDED	DO 100 MEM=2,NMEM			00132800 70.29
ADDED	IF(INODE(MEM).EQ.INODE(MEM-I)) GO TO 50			00132900 70.29
ADDED	INDEX=INODE(MEM)			00133000 70.29
ADDED	NNODES=NNODES+1			00133100 70.29
ADDED	50 CONTINUE			00133200 70.29
ADDED	NCON(INDEX)=NCON(INDEX)+1			00133300 70.29
ADDED	100 CONTINUE			00133400 70.29
ADDED	NNMAX=INODE(NMEM)			00133500 70.29
ADDED	C WRITE(6,8001) (INODE(I), MEMNQ(I), JNODE(I), I=1,NMEM)			00133600 70.29
ADDED	C WRITE(6,7999) (I,NCON(I),P(I),I=1,NNMAX)			00133700 70.29
ADDED	C7999 FORMAT(1H1,3H I ,2X,4HNCON,2X,2H P/(1X,13,3X,13,2X,F4.1))			00133800 70.29
ADDED	CALL BRANCH			00133900 70.29
ADDED	C WRITE(6,8002) NINOUT,(INOUT(I),I=1,NINOUT)			00134000 70.29
ADDED	C8002 FORMAT(1H0,'NINOUT=',I4,' INOUT=',5I12)			00134100 70.29
ADDED	IF(LEVEL.GT.1) STOP			00134200 70.29
ADDED	MMEM=NMEN			00134300 70.29
ADDED	NNODES=NNODES			00134400 70.29
ADDED	RETURN			00134500 70.29
ADDED	END			00134600 70.29
ADDED	SUBROUTINE BRANCH			00134700 70.29
ADDED	COMMON /MUFCON/			00134800 70.29
ADDED	1 A(3), COERR, IBRAN(850), IFLUID, CONSTS(3,600), GC, IOPT(10),			00134900 70.29
ADDED	2 IBCON(600), ITEMP, JBRPT(600), LABEL(20,3),			00135000 70.29
ADDED	3 LEVEL, MBRAN(850), NBRAN, NBRPTS, NPTSI(150), PBRPT(250),			00135100 70.29
ADDED	4 QBR(150), QERR, RHO(600), TBULK(500),			00135200 70.29
ADDED	5 TOLERR, VISC(600), XDOTA(500)			00135300 70.29
ADDED	COMMON /MUFCON/ INOUT(100), NINOUT, NDUMBP, LOOP			00135400 70.29
ADDED	COMMON /LICON/			00135500 70.29
ADDED	1 ALPHA(600), INODE(1200), JNODE(1200), MEMNQ(1200),			00135600 70.29
ADDED				00135700 70.29
ADDED				00135800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	2 NMEM,	NPLANE(600), P(500), PHI(600),	00135900 70.29
	ADDED	3 Q(600),	RADLEN(600), XYZ(500,3), IEND(150,2),	00136000 70.29
	ADDED	4 NENDS(2)		00136100 70.29
	ADDED	COMMON /ARCOM/		00136200 70.29
	ADDED	1	IFIND(500), IORDER(150), NCON(500),	00136300 70.29
	ADDED	2	NFIND(150)	00136400 70.29
	ADDED	DIMENSION	IBRPT(600)	00136500 70.29
	ADDED	DIMENSION	ICONST(3,600)	00136600 70.29
	ADDED	EQUIVALENCE (ICONST(1,1), CONSTS(1,1))		00136700 70.29
	ADDED	NE=0		00136800 70.29
	ADDED	NINOUT=0		00136900 70.29
	ADDED	NSUM=0		00137000 70.29
	ADDED	NBRPTS=0		00137100 70.29
	ADDED	C	CALCULATE NUMBER OF BRANCH POINTS, NBRPTS.	00137200 70.29
	ADDED	DO 180 I=1,NNMAX		00137300 70.29
	ADDED	INODE(I)=0		00137400 70.29
	ADDED	IFIND(I)=NSUM+1		00137500 70.29
	ADDED	NSUM=NSUM+NCON(I)		00137600 70.29
	ADDED	IF(NCON(I).LE.2) GO TO 180		00137700 70.29
	ADDED	IF(P(I).LT.0.0) GO TO 150		00137800 70.29
	ADDED	WRITE(6,9002) I		00137900 70.29
	ADDED	9002 FORMAT(1H0////1H0,107(1H*),PRESSURE AT BRANCH NODE ',I3,		00138000 70.29
	ADDED	1 * FIXED - ERRDR SCAN CONTINUES',1H0,107(1H*))		00138100 70.29
	ADDED	P(I)=-1.0		00138200 70.29
	ADDED	LEVEL=3		00138300 70.29
	ADDED	150 CONTINUE		00138400 70.29
	ADDED	NBRPTS=NBRPTS+1		00138500 70.29
	ADDED	INODE(I)=NBRPTS		00138600 70.29
	ADDED	180 CONTINUE		00138700 70.29
	ADDED	IF(NBRPTS.LE.100) GO TO 185		00138800 70.29
	ADDED	WRITE(6,9004)		00138900 70.29
	ADDED	9004 FORMAT(1H0////1H0,107(1H*),1H0,33X,*MORE THAN 100 BRANCH POINTS-',		00139000 70.29
	ADDED	1 * CASE SKIPPED',1H0,107(1H*))		00139100 70.29
	ADDED	LEVEL=4		00139200 70.29
	ADDED	RETURN		00139300 70.29
	ADDED	185 CONTINUE		00139400 70.29
	ADDED	C	TRACE ALL BRANCHES IN THE NETWORK	00139500 70.29
	ADDED	NRBP=0		00139600 70.29
	ADDED	INDEX=0		00139700 70.29
	ADDED	NUM=0		00139800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
	ADDED	NFIN=0		00139900 70.29
	ADDED	NDUMBP=0		00140000 70.29
	ADDED	NBRAN=0		00140100 70.29
	ADDED	DO 600 I=1,NNMAX		00140200 70.29
	ADDED	C	SKIP NON - EXISTANT NODES	00140300 70.29
	ADDED	IF(NCON(I).LE.0) GO TO 600		00140400 70.29
	ADDED	NST=NFIN+1		00140500 70.29
	ADDED	NFIN=NFIN+NCON(I)		00140600 70.29
	ADDED	WRITE(6,8001) I, NCON(I),NST,NFIN,INODE(I)		00140700 70.29
	ADDED	8001 FORMAT(1H0,'I=',13,' NCON(1)=' ,13,' NST=' ,13,' NFIN=' ,13,' INODE(1)'		00140800 70.29
	ADDED	1=',13)		00140900 70.29
	ADDED	IF(INODE(I).LE.0) GO TO 200		00141000 70.29
	ADDED	C	NODE HAS ALREADY BEEN ASSIGNED A BRANCH PT. NO.	00141100 70.29
	ADDED	NBRPT=INODE(I)		00141200 70.29
	ADDED	GO TO 250		00141300 70.29
	ADDED	200 CONTINUE		00141400 70.29
	ADDED	IF(P(I).GE.0.0) GO TO 230		00141500 70.29
	ADDED	IF(NCON(I)-2) 220,600,250		00141600 70.29
	ADDED	220 CONTINUE		00141700 70.29
	ADDED	N=IFIND(1)		00141800 70.29
	ADDED	IF(MEMNO(N).LE.0) GO TO 600		00141900 70.29
	ADDED	MEM=IABS(MEMNO(N))		00142000 70.29
	ADDED	IF(MOD(I*TYPE(MEM),100000000).GE.100000000) GO TO 230		00142100 70.29
	ADDED	WRITE(6,9010) I		00142200 70.29
	ADDED	9010 FORMAT(1H0,///1H0,107(1H*))/1H0,15X,'NO FLOW OR PRESSURE CONSTRAI',00142300 70.29		00142400 70.29
	ADDED	1 'NT SPECIFIED FOR NODE',14,' - ERROR SCAN CONTINUES'/1H0,		00142500 70.29
	ADDED	2 107(1H*))		00142600 70.29
	ADDED	LEVEL=3		00142700 70.29
	ADDED	P(I)=0.0		00142800 70.29
	ADDED	230 CONTINUE		00142900 70.29
	ADDED	C	ASSIGN A DUMMY BRANCH PT. NO. FOR FIXED PRESSURE	00143000 70.29
	ADDED	C	NODES OR END PT. NODES	00143100 70.29
	ADDED	NDUMBP=NDUMBP+1		00143200 70.29
	ADDED	NBRPT=NBRPTS+NDUMBP		00143300 70.29
	ADDED	PBRPT(NBRPT)=P(I)		00143400 70.29
	ADDED	IF(NCON(I).NE.1) GO TO 240		00143500 70.29
	ADDED	NINOUT=NINOUT+1		00143600 70.29
	ADDED	INOUT(NINOUT)=NBRPT		00143700 70.29
	ADDED	240 CONTINUE		00143800 70.29
	ADDED	INODE(I)=NBRPT		00143900 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	250 CONTINUE		00143900 70.29
	ADDED	WRITE(6,8002) NBRP,NDUMBP,NBRPT		00144000 70.29
	ADDED	8002 FORMAT(1H0,'NBRP=',13,' NDUMBP=',13,' NBRPT=',13)		00144100 70.29
	ADDED	C TRACE ALL BRANCHES ORIGINATING AT THIS NODE AND		00144200 70.29
	ADDED	C STORE NETWORK DATA AS FOLLOWS...		00144300 70.29
	ADDED	C BRANCH PT. NO. IBRAN(NUM) CONNECTED TO BRANCH PT.		00144400 70.29
	ADDED	C NO. JBRAN(NUM) BY BRANCH NO. IBCON(NUM)		00144500 70.29
	ADDED	DO 500 N=NST,NFIN		00144600 70.29
	ADDED	IF(MEMNO(N).LE.0) GO TO 500		00144700 70.29
	ADDED	C A BRANCH ORIGINATES AT THIS NODE - TRACE THE BRANCH		00144800 70.29
	ADDED	LAST=INDEX		00144900 70.29
	ADDED	NBRAN=NBRAN+1		00145000 70.29
	ADDED	IF(NBRAN.LE.150) GO TO 260		00145100 70.29
	ADDED	WRITE(6,9007)		00145200 70.29
	ADDED	9007 FORMAT(1H0,///1H0,107(1H*),1H0,25X,'MORE THAN 150 BRANCHES - CASE'		00145300 70.29
	ADDED	1 , ' SKIPPED',1H0,107(1H*))		00145400 70.29
	ADDED	LEVEL=4		00145500 70.29
	ADDED	RETURN		00145600 70.29
	ADDED	260 CONTINUE		00145700 70.29
	ADDED	JPOINT=N		00145800 70.29
	ADDED	C IF THE FIRST MEMBER IN THE BRANCH HAS A FIXED		00145900 70.29
	ADDED	C FLOWRATE, STORE THE FLOWRATE AND SET THE FLAG=-1		00146000 70.29
	ADDED	MEM=MEMNO(N)		00146100 70.29
	ADDED	IF(MOD(ITYPE(MEM),100000000).LT.10000000) GO TO 270		00146200 70.29
	ADDED	QBR(NBRAN)=Q(MEM)		00146300 70.29
	ADDED	KFIX=-1		00146400 70.29
	ADDED	GO TO 280		00146500 70.29
	ADDED	270 CONTINUE		00146600 70.29
	ADDED	KFIX=1		00146700 70.29
	ADDED	280 CONTINUE		00146800 70.29
	ADDED	IF(INDEX.GE.850) GO TO 303		00146900 70.29
	ADDED	IF(NCON(1).NE.1) GO TO 290		00147000 70.29
	ADDED	NE=NE+1		00147100 70.29
	ADDED	IEND(NE,1)=1		00147200 70.29
	ADDED	290 CONTINUE		00147300 70.29
	ADDED	INDEX=INDEX+1		00147400 70.29
	ADDED	IBRAN(INDEX)=I		00147500 70.29
	ADDED	300 CONTINUE		00147600 70.29
	ADDED	MBRAN(INDEX)=MEMNO(JPOINT)		00147700 70.29
	ADDED	C IPOINT IS THE NEXT NODE IN THE BRANCH		00147800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	IPOINT=JNODE(JPOINT)		00147900 70.29
	ADDED	INDEX=INDEX+1		00148000 70.29
	ADDED	IF(INDEX.LE.850) GO TO 304		00148100 70.29
	ADDED	303 CONTINUE		00148200 70.29
	ADDED	WRITE(6,9005)		00148300 70.29
	ADDED	9005 FORMAT(1H0////1H0,35X,'BRANCH STORAGE EXCEEDED - CASE SKIPPED',		00148400 70.29
	ADDED	1 1H0,107(1H*))		00148500 70.29
	ADDED	LEVEL=4		00148600 70.29
	ADDED	RETURN		00148700 70.29
	ADDED	304 CONTINUE		00148800 70.29
	ADDED	IBRAN(INDEX)=IPOINT		00148900 70.29
	ADDED	IF(NCON(IPOINT)-2) 320,310,400		00149000 70.29
	ADDED	310 CONTINUE		00149100 70.29
	ADDED	JPOINT=IFIND(IPCINT)		00149200 70.29
	ADDED	IF(P(IPOINT).LT.0.0) GO TO 315		00149300 70.29
	ADDED	IF(P(I).GE.0.0) GO TO 344		00149400 70.29
	ADDED	IF(KFIX.GT.0) GO TO 360		00149500 70.29
	ADDED	MEM=MEMNO(JPOINT)		00149600 70.29
	ADDED	IF(MEM.GT.0) GO TO 312		00149700 70.29
	ADDED	JPOINT=JPOINT+1		00149800 70.29
	ADDED	MEM=MEMNO(JPOINT)		00149900 70.29
	ADDED	IF(MEM.LE.0) GO TO 318		00150000 70.29
	ADDED	312 CONTINUE		00150100 70.29
	ADDED	I TYPE(MEM)=I TYPE(MEM)+10000000		00150200 70.29
	ADDED	Q(MEM)=Q(NBRAN)		00150300 70.29
	ADDED	GO TO 360		00150400 70.29
	ADDED	C THE BRANCH DOES NOT TERMINATE AT IPOINT - STORE		00150500 70.29
	ADDED	C MEMBER NO. AND SET POINTER TO NEXT POINT IN BRANCH		00150600 70.29
	ADDED	315 CONTINUE		00150700 70.29
	ADDED	IF(MEMNO(JPOINT).GT.0) GO TO 300		00150800 70.29
	ADDED	JPOINT=JPOINT+1		00150900 70.29
	ADDED	IF(MEMNO(JPOINT).GT.0) GO TO 300		00151000 70.29
	ADDED	318 CONTINUE		00151100 70.29
	ADDED	WRITE(6,9008) IPOINT, JNODE(JPOINT-1), JNODE(JPOINT)		00151200 70.29
	ADDED	9008 FORMAT(1H0////1H0,107(1H*))/1H0,22X,'NODES',14,' ',14,' AND',		00151300 70.29
	ADDED	1 14,' ARE CONNECTED ILLEGALLY - CASE SKIPPED',1H0,107(1H*))		00151400 70.29
	ADDED	LEVEL=4		00151500 70.29
	ADDED	RETURN		00151600 70.29
	ADDED	320 CONTINUE		00151700 70.29
	ADDED	C THE BRANCH TERMINATES AT IPOINT, WHICH IS AN		00151800 70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	C	END POINT NODE - CHECK FOR INCONSISTANT PRESSURE	00151900	70.29
ADDED	C	CCONSTRAINTS OR A SINGLE LOOP PROBLEM.	00152000	70.29
ADDED		IF(NCON(1).EQ.1) GO TO 330	00152100	70.29
ADDED		IF(P(IPOINT).GE.0.0) GO TO 360	00152200	70.29
ADDED		IF(KFIX.EQ.-1) GO TO 360	00152300	70.29
ADDED		WRITE(6,9010) IPOINT	00152400	70.29
ADDED		LEVEL=3	00152500	70.29
ADDED		P(IPOINT)=0.0	00152600	70.29
ADDED		GO TO 360	00152700	70.29
ADDED	330	CONTINUE	00152800	70.29
ADDED		IF(NDUMBP.EQ.1.AND.NBRPTS.EQ.0) GO TO 332	00152900	70.29
ADDED		LAST=LAST+1	00153000	70.29
ADDED		WRITE(6,9009) (IBRAN(IB),IB=LAST,INDEX)	00153100	70.29
ADDED	9009	FORMAT(1H1///1H0,107(1H*)/1H0,20X,'THE FOLLOWING BRANCH IS NOT ',(4X,2514))	00153200	70.29
ADDED	1	'CONNECTED TO THE NETWORK - CASE SKIPPED'/(4X,2514))	00153300	70.29
ADDED		LEVEL=4	00153400	70.29
ADDED		RETURN	00153500	70.29
ADDED	332	CONTINUE	00153600	70.29
ADDED	C	THIS IS A SINGLE LOOP PROBLEM	00153700	70.29
ADDED		IF(P(IPOINT)) 334,336,336	00153800	70.29
ADDED	334	CONTINUE	00153900	70.29
ADDED		IF(P(1)) 340,338,338	00154000	70.29
ADDED	336	CONTINUE	00154100	70.29
ADDED		IF(P(1)) 338,342,342	00154200	70.29
ADDED	338	CONTINUE	00154300	70.29
ADDED		IF(KFIX+1) 340,346,340	00154400	70.29
ADDED	340	CONTINUE	00154500	70.29
ADDED		WRITE(6,9010) IPOINT	00154600	70.29
ADDED		LEVEL=4	00154700	70.29
ADDED		RETURN	00154800	70.29
ADDED	342	CONTINUE	00154900	70.29
ADDED		IF(KFIX+1) 346,344,346	00155000	70.29
ADDED	344	CONTINUE	00155100	70.29
ADDED	C	INCONSISTANT PRESSURE CONSTRAINTS	00155200	70.29
ADDED		WRITE(6,9003) 1, IPOINT	00155300	70.29
ADDED	9003	FORMAT(1H0///1H0,107(1H*)/1H0,23X,'2 NODES IN THE SAME BRANCH, ',(4X,2514))	00155400	70.29
ADDED	1	I4,' AND',I4,' HAVE FIXED PRESSURES - ERROR SCAN CONTINUES'/1H0,	00155500	70.29
ADDED	2	107(1H*))	00155600	70.29
ADDED		LEVEL=3	00155700	70.29
ADDED		IF(NCON(IPOINT).EQ.1) GO TO 360	00155800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	P(IPOINT)=-1.0		00155900 70.29
	ADDED	GO TO 315		00156000 70.29
	ADDED	346 CONTINUE		00156100 70.29
	ADDED	LEVEL=1		00156200 70.29
	ADDED	NBCON(1)=1		00156300 70.29
	ADDED	NBCON(2)=1		00156400 70.29
	ADDED	360 CONTINUE		00156500 70.29
	ADDED	C	STORE NETWORK DATA FOR THIS BRANCH	00156600 70.29
	ADDED	IF(INODE(IPOINT).GT.0) GO TO 370		00156700 70.29
	ADDED	C	ASSIGN DUMMY BRANCH PT. NO. TO IPOINT	00156800 70.29
	ADDED	NDUMBP=NDUMBP+1		00156900 70.29
	ADDED	JBP=NBRPTS+NDUMBP		00157000 70.29
	ADDED	INODE(IPOINT)=JBP		00157100 70.29
	ADDED	PBRPT(JBP)=P(IPOINT)		00157200 70.29
	ADDED	IF(NCON(IPOINT).NE.1) GO TO 410		00157300 70.29
	ADDED	NINOUT=NINOUT+1		00157400 70.29
	ADDED	INOUT(NINOUT)=JBP		00157500 70.29
	ADDED	GO TO 410		00157600 70.29
	ADDED	370 CONTINUE		00157700 70.29
	ADDED	C	USE PREVIOUSLY ASSIGNED BRANCH PT. NUMBER	00157800 70.29
	ADDED	JBP=INODE(IPOINT)		00157900 70.29
	ADDED	GO TO 410		00158000 70.29
	ADDED	400 CONTINUE		00158100 70.29
	ADDED	C	THIS BRANCH TERMINATES AT IPOINT WHICH IS A BRANCH	00158200 70.29
	ADDED	C	POINT - STORE NETWORK DATA FOR THIS BRANCH	00158300 70.29
	ADDED	C	USE BRANCH PT. NO. PREVIOUSLY ASSIGNED	00158400 70.29
	ADDED	JBP=INODE(IPOINT)		00158500 70.29
	ADDED	C	STORE INFO FOR TEES	00158600 70.29
	ADDED	MNEG=0		00158700 70.29
	ADDED	JST=IFIND(IPOINT)		00158800 70.29
	ADDED	JFIN=JST+NCON(IPOINT)-1		00158900 70.29
	ADDED	DO 402 J=JST,JFIN		00159000 70.29
	ADDED	IF(MEMNO(J).GT.0) GO TO 402		00159100 70.29
	ADDED	IF(MNEG.NE.0) GO TO 410		00159200 70.29
	ADDED	MNEG=1		00159300 70.29
	ADDED	402 CONTINUE		00159400 70.29
	ADDED	DO 406 J=JST,JFIN		00159500 70.29
	ADDED	MEM=MEMNO(J)		00159600 70.29
	ADDED	IF(MEM.LE.0) GO TO 406		00159700 70.29
	ADDED	IT=MOD(ITYPE(MEM),10000)		00159800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	IF(IT.LT.100) GO TO 406			00159900 70.29
ADDED	IF(IT.GT.1300) GO TO 406			00160000 70.29
ADDED	ICONST(3, MEM)=ICONST(3, MEM)+NBRAN*1000000			00160100 70.29
ADDED	406 CONTINUE			00160200 70.29
ADDED	410 CONTINUE			00160300 70.29
ADDED	IF(NUM+2.LE.300) GO TO 420			00160400 70.29
ADDED	WRITE(6, 9006)			00160500 70.29
ADDED	9006 FORMAT(1H0///1H0,107(1H*)/1H0,30X,'MORE THAN 150 BRANCHES IN',			00160600 70.29
ADDED	1, NETWORK - CASE SKIPPED*/1H0,107(1H*))			00160700 70.29
ADDED	LEVEL=4			00160800 70.29
ADDED	RETURN			00160900 70.29
ADDED	420 CONTINUE			00161000 70.29
ADDED	C		STORE THE FORWARD CONNECTION, NBRPT=IO-JBP BY NBRAN	00161100 70.29
ADDED	NUM=NUM+1			00161200 70.29
ADDED	IBRPT(NUM)=NBRPT			00161300 70.29
ADDED	IBCON(NUM)=NBRAN			00161400 70.29
ADDED	JBRPT(NUM)=JBP			00161500 70.29
ADDED	WRITE(6, 8004) NUM, IBRPT(NUM), IBCON(NUM), JBRPT(NUM)			00161600 70.29
ADDED	8004 FORMAT(1H0,'NUM, IBRPT, IBCON, JBRPT', 4I12)			00161700 70.29
ADDED	430 CONTINUE			00161800 70.29
ADDED	C		STORE THE REVERSE CONNECTION, JBP=IO-NBRPT BY -NBRAN	00161900 70.29
ADDED	NUM=NUM+1			00162000 70.29
ADDED	IBRPT(NUM)=JBP			00162100 70.29
ADDED	IBCON(NUM)=-NBRAN			00162200 70.29
ADDED	JBRPT(NUM)=NBRPT			00162300 70.29
ADDED	WRITE(6, 8004) NUM, IBRPT(NUM), IBCON(NUM), JBRPT(NUM)			00162400 70.29
ADDED	450 CONTINUE			00162500 70.29
ADDED	C		CALCULATE NO. OF NODES INT THIS BRANCH	00162600 70.29
ADDED	NPTS(NBRAN)=KFIX*(INDEX-LAST)			00162700 70.29
ADDED	IF(LEVEL.EQ.1) RETURN			00162800 70.29
ADDED	500 CONTINUE			00162900 70.29
ADDED	600 CONTINUE			00163000 70.29
ADDED	C		SORT ARRAYS TO MAKE ALL BRANCH PT. NOS. CONTIGUOUS	00163100 70.29
ADDED	CALL SORT(3, NUM, IBRPT, IBCON, JBRPT)			00163200 70.29
ADDED	C		COUNT THE NO. OF BRANCHES CONNECTED TO EACH BRANCH	00163300 70.29
ADDED	C		POINT AND STORE IN NBCON	00163400 70.29
ADDED	IB=1			00163500 70.29
ADDED	NBCON(1)=1			00163600 70.29
ADDED	DO 700 I=2, NUM			00163700 70.29
ADDED	IF(IBRPT(I).EQ.IBRPT(I-1)) GO TO 650			00163800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	IB=IBRPT(1)		00163900 70.29
	ADDED	NBCON(IB)=1		00164000 70.29
	ADDED	GO TO 700		00164100 70.29
	ADDED	650 CONTINUE		00164200 70.29
	ADDED	NBCON(IB)=NBCON(IB)+1		00164300 70.29
	ADDED	700 CONTINUE		00164400 70.29
	ADDED	C	CHECK BRANCH FLOW CONSTRAINTS (IF ANY)	00164500 70.29
	ADDED	NENDS(1)=NE		00164600 70.29
	ADDED	RETURN		00164700 70.29
	ADDED	END		00164800 70.29
	ADDED	SUBROUTINE LNK2		00164900 70.29
	ADDED	COMMON /MUFCON/		00165000 70.29
	ADDED	1 A(3),	COERK, CONSTS(3,600), GC,	00165100 70.29
	ADDED	2 IBCON(600),	IFLUID, IOPT(10),	00165200 70.29
	ADDED	3 ITEMP,	JBRPT(600), LABEL(20,3),	00165300 70.29
	ADDED	4 LEVEL,	NBRAN(850),	00165400 70.29
	ADDED	5 NBRPTS,	NNMAX, PBRPT(250),	00165500 70.29
	ADDED	6 QBR(150),	QERR, RHO(600),	00165600 70.29
	ADDED	7 TOLERR,	XDOTA(500)	00165700 70.29
	ADDED	COMMON /MUFCON/	INOUT, NDUMBP, LOOP	00165800 70.29
	ADDED	COMMON /L2CON/	BRDP(150), POTHE(150),	00165900 70.29
	ADDED	QERR=1.0	IFIND(250)	00166000 70.29
	ADDED	NFIN=0		00166100 70.29
	ADDED	DO 100 IB=1,NBRAN		00166200 70.29
	ADDED	NST=NFIN+1		00166300 70.29
	ADDED	NFIN=NFIN+IABS(NPTS(IB))		00166400 70.29
	ADDED	NSTOP=NFIN-1		00166500 70.29
	ADDED	POTHE(IB)=0.0		00166600 70.29
	ADDED	BRDP(IB)=0.0		00166700 70.29
	ADDED	DO 50 N=NST,NSTOP		00166800 70.29
	ADDED	M=MBRAN(N)		00166900 70.29
	ADDED	I1=IBRAN(N)		00167000 70.29
	ADDED	I2=IBRAN(N+1)		00167100 70.29
	ADDED	POTHE(IB)=POTHE(IB)+RHO(M)*(XDOTA(I2)-XDOTA(I1))		00167200 70.29
	ADDED	50 CONTINUE		00167300 70.29
	ADDED	M=MBRAN(NST)		00167400 70.29
	ADDED	IF(MOD(ITYPE(M),100000000).GE.10000000) GO TO 100		00167500 70.29
	ADDED	QBR(IB)=1000.0		00167600 70.29
	ADDED	100 CONTINUE		00167700 70.29
	ADDED	IFIND(1)=1		00167800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DDI
ADDED	IF(LEVEL.EQ.1.AND.NPTS(1).LT.0) RETURN			00167900 70.29
ADDED	DO 200 I=2,NBRAN			00168000 70.29
ADDED	IFIND(I)=IFIND(I-1)+IABS(NPTS(I-1))			00168100 70.29
ADDED	200 CONTINUE			00168200 70.29
ADDED	CALL SPSOLV			00168300 70.29
ADDED	RETURN			00168400 70.29
ADDED	END			00168500 70.29
ADDED	FUNCTION RNAT1(X)			00168600 70.29
ADDED	DIMENSION TEMP(8), RNAKT(8), VNAKT(8)			00168700 70.29
ADDED	DATA TEMP/ 200., 400., 600., 800., 1000., 1200., 1400., 0.0/00168800			70.29
ADDED	DATA RNAKT/ 53., 51.82, 49.64, 48., 46.31, 44.64, 42.96, 0./00168900			70.29
ADDED	DATA VNAKT/ 1.17, .78, .58, .48, .418, .364, .31, 0.0/			00169000 70.29
ADDED	ENTRY RNAT (TEMP, ISTEP, IERR)			00169100 70.29
ADDED	IERR = 1			00169200 70.29
ADDED	RNAT1 = 53.0			00169300 70.29
ADDED	RNAT=RNAT1			00169400 70.29
ADDED	IF (TEMP .LT. 200.0) GO TO 10			00169500 70.29
ADDED	RNAT1 = 42.96			00169600 70.29
ADDED	RNAT=RNAT1			00169700 70.29
ADDED	IF (TEMP .GT. 1400.0) GO TO 10			00169800 70.29
ADDED	CALL INT4 (TEMPA,RNAKT, TEMP, ANS)			00169900 70.29
ADDED	RNAT = ANS			00170000 70.29
ADDED	RETURN			00170100 70.29
ADDED	ENTRY VNAT (TEMP, ISTEP, IERR)			00170200 70.29
ADDED	IERR =1			00170300 70.29
ADDED	RNAT1 = 1.17 / 3600.0			00170400 70.29
ADDED	VNAT=RNAT1			00170500 70.29
ADDED	IF (TEMP .LT. 200.0) GO TO 10			00170600 70.29
ADDED	RNAT1 = 0.31 / 3600.0			00170700 70.29
ADDED	VNAT=RNAT1			00170800 70.29
ADDED	IF (TEMP .GT. 1400.0) GO TO 10			00170900 70.29
ADDED	CALL INT4 (TEMPA, VNAKT, TEMP, ANS)			00171000 70.29
ADDED	VNAT = ANS / 3600.0			00171100 70.29
ADDED	RETURN			00171200 70.29
ADDED	C			00171300 70.29
ADDED	C ERROR MESSAGE			00171400 70.29
ADDED	10 WRITE (6,1000) TEMP, ISTEP, RNAT1			00171500 70.29
ADDED	1000 FORMAT (100(1H#)/ 1H0,103THE RANGE OF TEMPERATURE VALUES FOR LIQUID			00171600 70.29
ADDED	110 SODIUM HAVE BEEN EXCEEDED AND INTERPOLATION IS NOT POSSIBLE /			00171700 70.29
ADDED	2 1H0, 7HTEMP = , F10.2, 10X, 8HISTEP = , 15, 10X, 11HFUNCTION = ,			00171800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DDI
ADDED	3 F10.5/)			00171900 70.29
ADDED	IERR = 2			00172000 70.29
ADDED	RETURN			00172100 70.29
ADDED	END			00172200 70.29
ADDED	FUNCTION RHGLT1(X)			00172300 70.29
ADDED	DIMENSION TEMPA (10), RHUGLT(10), VISGLT(10)			00172400 70.29
ADDED	DATA TEMPA/ 50., 100., 200., 400., 600., 800., 1000., 1200.,			00172500 70.29
ADDED	1 1250., 0.0/			00172600 70.29
ADDED	DATA RHUGLT/ 848., 843., 835., 817.5, 801., 784., 753.,			00172700 70.29
ADDED	1 749.5, 0.0/			00172800 70.29
ADDED	DATA VISGLT/ 3.87, 3.5, 3.03, 2.48, 2.26, 1.96, 1.82, 1.725, 1.7,			00172900 70.29
ADDED	1 0.0/			00173000 70.29
ADDED	ENTRY RHGLT (TEMP, ISTEP, IERR)			00173100 70.29
ADDED	IERR = 1			00173200 70.29
ADDED	RHGLT1 = 848.0			00173300 70.29
ADDED	RHGLT=RHGLT1			00173400 70.29
ADDED	IF (TEMP .LT. 50.0) GO TO 10			00173500 70.29
ADDED	RHGLT1 = 749.5			00173600 70.29
ADDED	RHGLT=RHGLT1			00173700 70.29
ADDED	IF (TEMP .GT. 1250.0) GO TO 10			00173800 70.29
ADDED	CALL INT4 (TEMPA, RHUGLT, TEMP, ANS)			00173900 70.29
ADDED	RHGLT = ANS			00174000 70.29
ADDED	RETURN			00174100 70.29
ADDED	ENTRY VHGLT (TEMP, ISTEP, IERR)			00174200 70.29
ADDED	IERR = 1			00174300 70.29
ADDED	RHGLT1 = 3.87 / 3600.0			00174400 70.29
ADDED	VHGLT=RHGLT1			00174500 70.29
ADDED	IF (TEMP .LT. 50.0) GO TO 10			00174600 70.29
ADDED	RHGLT1 = 1.7 / 3600.0			00174700 70.29
ADDED	VHGLT=RHGLT1			00174800 70.29
ADDED	IF (TEMP .GT. 1250.0) GO TO 10			00174900 70.29
ADDED	CALL INT4 (TEMPA, VISGLT, TEMP, ANS)			00175000 70.29
ADDED	VHGLT = ANS / 3600.0			00175100 70.29
ADDED	RETURN			00175200 70.29
ADDED	C			00175300 70.29
ADDED	C ERROR MESSAGE			00175400 70.29
ADDED	10 WRITE (6,1000) TEMP, ISTEP, RHGLT1			00175500 70.29
ADDED	1000 FORMAT(1X,100(1H*))1X,104THE RANGE OF TEMPERATURE VALUES FOR LIQUID			00175600 70.29
ADDED	1000 MERCURY HAVE BEEN EXCEEDED AND INTERPOLATION IS NOT POSSIBLE /			00175700 70.29
ADDED	2 1H0, 7HTEMP = , F10.2, 10X, 8HISTEP = , 15, 10X, 11HFUNCTION =			00175800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	1 , F10.5/)		00175900 70.29
	ADDED	IERR = 2		00176000 70.29
	ADDED	RETURN		00176100 70.29
	ADDED	END		00176200 70.29
	ADDED	FUNCTION R4P3E (X)		00176300 70.29
	ADDED	DIMENSION TEMP( 9), RHOP3E( 9), VISP3E( 9)		00176400 70.29
	ADDED	DATA TEMP / 100., 150., 200., 300., 400., 500., 600., 700., 0.0/		00176500 70.29
	ADDED	DATA RHOP3E/ 72.8, 71.7, 70.3, 66.45, 64.6, 61.6, 58.8, 55.9, 0.0/00176600		70.29
	ADDED	DATA VISP3E/ 175., 43., 17.2, 6.45, 3.4, 2.04, 1.35, 1.04, 0.0/		00176700 70.29
	ADDED	ENTRY R4P3ET (TEMP, ISTEP, IERR)		00176800 70.29
	ADDED	IERR = 1		00176900 70.29
	ADDED	R4P3E = 72.8		00177000 70.29
	ADDED	R4P3ET=R4P3E		00177100 70.29
	ADDED	IF (TEMP .LT. 100.0) GO TO 10		00177200 70.29
	ADDED	R4P3E = 55.9		00177300 70.29
	ADDED	R4P3ET=R4P3E		00177400 70.29
	ADDED	IF (TEMP .GT. 700.0) GO TO 10		00177500 70.29
	ADDED	CALL INT4 ( TEMP, RHOP3E, TEMP, ANS)		00177600 70.29
	ADDED	R4P3ET= ANS		00177700 70.29
	ADDED	RETURN		00177800 70.29
	ADDED	ENTRY V4P3ET (TEMP, ISTEP, IERR)		00177900 70.29
	ADDED	IERR = 1		00178000 70.29
	ADDED	R4P3E = 175.0 / 3600.0		00178100 70.29
	ADDED	V4P3ET=R4P3E		00178200 70.29
	ADDED	IF (TEMP .LT. 100.0) GO TO 10		00178300 70.29
	ADDED	R4P3E = 1.04 / 3600.0		00178400 70.29
	ADDED	V4P3ET=R4P3E		00178500 70.29
	ADDED	IF (TEMP .GT. 700.0) GO TO 10		00178600 70.29
	ADDED	CALL INT4 (TEMP, VISP3E, TEMP, ANS)		00178700 70.29
	ADDED	V4P3ET= ANS / 3600.0		00178800 70.29
	ADDED	RETURN		00178900 70.29
	ADDED	C		00179000 70.29
	ADDED	C ERROR MESSAGE		00179100 70.29
	ADDED	10 WRITE (6, 1000) TEMP, ISTEP, R4P3E		00179200 70.29
	ADDED	1000 FORMAT(1X,100(IH*))/1X,100THE RANGE OF TEMPERATURE VALUES FOR MIX		00179300 70.29
	ADDED	1- 4P3E HAVE BEEN EXCEEDED AND INTERPOLATION IS NOT POSSIBLE / 1H0,00179400		70.29
	ADDED	2 7HTEMP = , F10.2, 10X, 8HISTEP = , 15, 10X, 11HFUNCTION = , F10.500179500		70.29
	ADDED	3 /)		00179600 70.29
	ADDED	IERR = 2		00179700 70.29
	ADDED	RETURN		00179800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	ADDED	END	00179900	70.29
ADDED	ADDED	FUNCTION H2OT(X)	00180000	70.29
ADDED	ADDED	DIMENSION TEMPA (16), RHOH2O (16), VISH2O (16)	00180100	70.29
ADDED	ADDED	DATA TEMPA/ 32., 40., 60., 80., 100., 150., 200., 250., 300.,	00180200	70.29
ADDED	ADDED	1 350., 400., 450., 500., 550., 600., 0.0/	00180300	70.29
ADDED	ADDED	DATA RHOH2O/ 62.4, 62.4, 62.4, 62.3, 62.2, 62.0, 61.2, 60.1, 58.8, 57.3, 00180400	00180400	70.29
ADDED	ADDED	1 55.6, 53.6, 51.6, 49.0, 45.9, 42.4, 0.0/	00180500	70.29
ADDED	ADDED	DATA VISH2O/ .0012, .00104, .00076, .000578, 0.000458, .000292,	00180600	70.29
ADDED	ADDED	1 .000205, .000158, .000126, .000105, .000091, .000080, .000071,	00180700	70.29
ADDED	ADDED	2 .000064, .000058, 0.0/	00180800	70.29
ADDED	ADDED	ENTRY RH2OT (TEMP, ISTEP, IERR)	00180900	70.29
ADDED	ADDED	IERR = 1	00181000	70.29
ADDED	ADDED	H2OT = 62.4	00181100	70.29
ADDED	ADDED	RH2OT=H2OT	00181200	70.29
ADDED	ADDED	IF (TEMP .LT. 32.0) GO TO 10	00181300	70.29
ADDED	ADDED	H2OT = 42.4	00181400	70.29
ADDED	ADDED	RH2OT=H2OT	00181500	70.29
ADDED	ADDED	IF (TEMP .GT. 600.0) GO TO 10	00181600	70.29
ADDED	ADDED	CALL INT4 (TEMPA, RHOH2O, TEMP, ANS)	00181700	70.29
ADDED	ADDED	RH2OT= ANS	00181800	70.29
ADDED	ADDED	RETURN	00181900	70.29
ADDED	ADDED	ENTRY VH2OT (TEMP, ISTEP, IERR)	00182000	70.29
ADDED	ADDED	IERR = 1	00182100	70.29
ADDED	ADDED	H2OT = .0012	00182200	70.29
ADDED	ADDED	VH2OT=H2OT	00182300	70.29
ADDED	ADDED	IF (TEMP .LT. 32.0) GO TO 10	00182400	70.29
ADDED	ADDED	H2OT = .000058	00182500	70.29
ADDED	ADDED	VH2OT=H2OT	00182600	70.29
ADDED	ADDED	IF (TEMP .GT. 600.0) GO TO 10	00182700	70.29
ADDED	ADDED	CALL INT4 (TEMPA, VISH2O, TEMP, ANS)	00182800	70.29
ADDED	ADDED	VH2OT= ANS	00182900	70.29
ADDED	ADDED	RETURN	00183000	70.29
ADDED	C	C ERROR MESSAGE	00183100	70.29
ADDED	C	C	00183200	70.29
ADDED	C	C	00183300	70.29
ADDED	ADDED	10 WRITE (6,1000) TEMP, ISTEP, H2OT	00183400	70.29
ADDED	ADDED	1000 FORMAT (IX, 100(IH*))/ IX, 93HIGH RANGE OF TEMPERATURE VALUES FOR	00183500	70.29
ADDED	ADDED	IH2O HAVE BEEN EXCEEDED AND INTERPOLATION IS NOT POSSIBLE / IH0,	00183600	70.29
ADDED	ADDED	2 7HTEMP = , F10.2, 10X, 8HISTEP = , 15, 10X, 11HFUNCTION = , F10.5)00183700	00183700	70.29
ADDED	ADDED	IERR = 2	00183800	70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	RETURN	00183900	70.29
	ADDED	END	00184000	70.29
	ADDED	FUNCTION FLARB (X)	00184100	70.29
	ADDED	COMMON /FARB/ FRHO(10), FVISC(10), FTEMP(10)	00184200	70.29
	ADDED	ENTRY RARBT (TEMP, ISTEP, IERR)	00184300	70.29
	ADDED	IERR = 1	00184400	70.29
	ADDED	FLARB = FRHO(1)	00184500	70.29
	ADDED	RARBT=FLARB	00184600	70.29
	ADDED	IF ( TEMP .LT. FTEMP(1)) GO TO 10	00184700	70.29
	ADDED	FLARB = FRHO(9)	00184800	70.29
	ADDED	RARBT=FLARB	00184900	70.29
	ADDED	IF (TEMP .GT. FTEMP(9)) GO TO 10	00185000	70.29
	ADDED	CALL INT4 (FTEMP, FRHO, TEMP, ANS)	00185100	70.29
	ADDED	RARBT = ANS	00185200	70.29
	ADDED	RETURN	00185300	70.29
	ADDED	ENTRY VARBT (TEMP, ISTEP, IERR)	00185400	70.29
	ADDED	IERR = 1	00185500	70.29
	ADDED	FLARB = FVISC(1)	00185600	70.29
	ADDED	VARBT=FLARB	00185700	70.29
	ADDED	IF (TEMP .LT. FTEMP(1)) GO TO 10	00185800	70.29
	ADDED	FLARB = FVISC(9)	00185900	70.29
	ADDED	VARBT=FLARB	00186000	70.29
	ADDED	IF (TEMP .GT. FTEMP(9)) GO TO 10	00186100	70.29
	ADDED	CALL INT4 (FTEMP, FVISC, TEMP, ANS)	00186200	70.29
	ADDED	VARBT = ANS	00186300	70.29
	ADDED	RETURN	00186400	70.29
	ADDED	C	00186500	70.29
	ADDED	C ERROR MESSAGE	00186600	70.29
	ADDED	C	00186700	70.29
	ADDED	10 WRITE (6,1000) TEMP, ISTEP, FLARB	00186800	70.29
	ADDED	1000 FORMAT (1X, 100(1H*)) 1X, 46HTHIS TEMPERATURE EXCEEDS ITS ESTABLISHED RANGE, 10X, 7HTEMP = , F10.3/ 1H0, 33HPROGRAM IS IN EXECUTION	00186900	70.29
	ADDED	2STEP NO. , 16, 4X, 33HTHE DESIRED VALUE HAS BEEN SET TO, F10.5/1X, 3 100(1H*))	00187000	70.29
	ADDED	IERR = 2	00187100	70.29
	ADDED	RETURN	00187200	70.29
	ADDED	END	00187300	70.29
	ADDED	SUBROUTINE SPSOLV	00187400	70.29
	ADDED	REAL*8 BMATRX, FLINBP, PDUBL	00187500	70.29
	ADDED	COMMON /MUFCON/	00187600	70.29
	ADDED		00187700	70.29
	ADDED		00187800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ MESSAGE

FILENAME=MUFAN

DECKNAME=MUFAN

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ADDED 1 A(3), TOLABS, CONSTS(3,600), GC, 00187900 70.29
ADDED 2 IBCON(600), IBRAN(850), IFLUID, IOPT(10), 00188000 70.29
ADDED 3 ITEMP, ITYPE(600), JBRPT(600), LABEL(20,3), 00188100 70.29
ADDED 4 LEVEL, MBRAN(850), NBRAN, 00188200 70.29
ADDED 5 NBRPTS, NNMAX, NPTS(150), PBRPT(250), 00188300 70.29
ADDED 6 QBR(150), QERR, RHO(600), TBULK(500), 00188400 70.29
ADDED 7 TOLERR, VISC(600), XDOTA(500) 00188500 70.29
ADDED COMMON /MUFCON/ INOUT(100), NINOUT, NDUMBP, LOOP 00188600 70.29
ADDED COMMON /L2COM/ BRDP(150), POTHED(150), IFIND(250) 00188700 70.29
ADDED COMMON /PQCHAR/ 00188800 70.29
ADDED 1 PCHAR(11,50), PCMAX(50), QCHAR(11,50), QCMAX(50) 00188900 70.29
ADDED COMMON /PQCHAR/ PCMIN(50), QCMIN(50) 00189000 70.29
ADDED DIMENSION BMATRIX( 70, 70), BRCOM(150), FLINBP(100) 00189100 70.29
ADDED DIMENSION DPUMP(150), PDUBL(70) 00189200 70.29
ADDED DIMENSION ICONST(3,600) 00189300 70.29
ADDED EQUIVALENCE (ICONST(1,1), CONSTS(1,1)) 00189400 70.29
ADDED EQUIVALENCE (LIMIT,IUPT(1)), (INFI,IUPT(2)) 00189500 70.29
ADDED ITER8=0 00189600 70.29
ADDED INIT=1 00189700 70.29
ADDED NDO=NBPRPTS+NDUMBP 00189800 70.29
ADDED DO 40 I=NBPRPTS,NDO 00189900 70.29
ADDED PDUBL(I)=DBLE(PBRPT(I)) 00190000 70.29
ADDED 40 CONTINUE 00190100 70.29
ADDED C ZERO OUT PUMP PRESSURE RISE ARRAY 00190200 70.29
ADDED DO 50 I=1,NBRAN 00190300 70.29
ADDED DPUMP(I)=0.0 00190400 70.29
ADDED 50 CONTINUE 00190500 70.29
ADDED 100 CONTINUE 00190600 70.29
ADDED RELMAX=0.0 00190700 70.29
ADDED MAXERR=1 00190800 70.29
ADDED C ZERO OUT CONDUCTANCE MATRIX 00190900 70.29
ADDED DO 150 I=1,NBRPTS 00191000 70.29
ADDED DO 150 J=1,NBRPTS 00191100 70.29
ADDED BMATRIX(I,J)=0.000 00191200 70.29
ADDED 150 CONTINUE 00191300 70.29
ADDED C WRITE(6,8000) ITER8 00191400 70.29
ADDED C8000 FORMAT(1H1,45(1H*),14,'TH ITERATION',45(1H*)) 00191500 70.29
ADDED NFIN=0 00191600 70.29
ADDED C COMPUTE CONDUCTANCES OF ALL BRANCHES 00191700 70.29
ADDED C WITH UNCONSTRAINED FLOW RATES. 00191800 70.29

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OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	NBP2=0		00191900 70.29
	ADDED	DO 250 IBP=1, NDO		00192000 70.29
	ADDED	NBP1=NBP2+1		00192100 70.29
	ADDED	NBP2=NBP2+IABS(NBCON(IBP))		00192200 70.29
	ADDED	DO 250 NBP=NBP1,NBP2		00192300 70.29
	ADDED	IF(IBCON(NBP).LE.0) GO TO 250		00192400 70.29
	ADDED	IB=IBCON(NBP)		00192500 70.29
	ADDED	IF(NPTS(IB).LE.0) GO TO 250		00192600 70.29
	ADDED	NST=IFIND(IB)		00192700 70.29
	ADDED	NFIN=NST+IABS(NPTS(IB))-1		00192800 70.29
	ADDED	QB=ABS(QBR(IB))		00192900 70.29
	ADDED	BRRES=0.0		00193000 70.29
	ADDED	LASTM=NFIN-1		00193100 70.29
	ADDED	DO 200 N=NST, LASTM		00193200 70.29
	ADDED	MEM=MBRAN(N)		00193300 70.29
	ADDED	IT=MOD(ITYPE(MEM),100000000)		00193400 70.29
	ADDED	IF(ITYPE(MEM).NE.300000000) GO TO 158		00193500 70.29
	ADDED	DPUMP(IB)=CONSTS(2, MEM)		00193600 70.29
	ADDED	GO TO 200		00193700 70.29
	ADDED	158 CONTINUE		00193800 70.29
	ADDED	IF(IT.LT.1000000) GO TO 180		00193900 70.29
	ADDED	IT=IT/100000 +41		00194000 70.29
	ADDED	160 CONTINUE		00194100 70.29
	ADDED	IF(ITER8.GT.0) GO TO 162		00194200 70.29
	ADDED	DPUMP(IB)=(PCMIN(IT)+PCMAX(IT))/2.0		00194300 70.29
	ADDED	GO TO 164		00194400 70.29
	ADDED	162 CONTINUE		00194500 70.29
	ADDED	DPUMP(IB)=0.5*(PIABLE(IT,QB)+DPUMP(IB))		00194600 70.29
	ADDED	164 CONTINUE		00194700 70.29
	ADDED	GO TO 200		00194800 70.29
	ADDED	180 CONTINUE		00194900 70.29
	ADDED	190 CONTINUE		00195000 70.29
	ADDED	BRRES=BRRES+RESIST(MEM,QB,INIT)		00195100 70.29
DEBGO 1	ADDED	C WRITE(6,8001) IB,BRRES		00195200 70.29
	ADDED	C8001 FORMAT(1X,'DEBUG01 IB=',I4,' BRRES=',G13.6)		00195300 70.29
	ADDED	200 CONTINUE		00195400 70.29
	ADDED	IF(ABS(BRRES).LT.1.0E-20) BRRES=SIGN(1.0E-20,BRRES)		00195500 70.29
	ADDED	BRCON(IB)=1.0/BRRES		00195600 70.29
	ADDED	250 CONTINUE		00195700 70.29
	ADDED	INIT=2		00195800 70.29

OLD VOL=SER=004783		DRC UPDATE		NEW VOL=SER=007208	
OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD	
DEBUG02	ADDED	C	WRITE(6,8002) (ID,BRCON(ID),ID=1,NBRAN)	00195900	70.29
	ADDED	C8002	FORMAT(1X,'DEBUG02 BRANCH BRCON'/(11X,I4,4X,G13.6))	00196000	70.29
	ADDED		IF(LEVEL.EQ.1) GO TO 750	00196100	70.29
	ADDED	C		00196200	70.29
	ADDED	C	SET UP MATRIX OF BRANCH CONDUCTANCES FOR	00196300	70.29
	ADDED	C	NODE EQUATIONS AND VECTOR OF INFLOWS TO	00196400	70.29
	ADDED	C	EACH NODE. THE NODES ARE THE REAL BRANCH	00196500	70.29
	ADDED	C	POINTS IN THE NETWORK.	00196600	70.29
	ADDED	C		00196700	70.29
	ADDED		NFIN=0	00196800	70.29
	ADDED		DO 650 IBRPT=1,NBRPTS	00196900	70.29
	ADDED		FLINBP(IBRPT)=0.000	00197000	70.29
	ADDED		NST=NFIN+1	00197100	70.29
	ADDED		NFIN=NFIN+IABS(NBCON(IBRPT))	00197200	70.29
	ADDED		280 CONTINUE	00197300	70.29
	ADDED		DO 600 N=NST,NFIN	00197400	70.29
	ADDED		J=JBRPT(N)	00197500	70.29
	ADDED		JBC=IBCON(N)	00197600	70.29
	ADDED		IBC=IABS(JBC)	00197700	70.29
	ADDED		SGN=JBC/IBC	00197800	70.29
DEBUG05	ADDED	C	WRITE(6,8005) J, JBC, NBCON(IBRPT)	00197900	70.29
	ADDED	C8005	FORMAT(1X,'DEBUG05 J=',I4,' JBC=',I4,' NBCON(IBRPT)=' ,I4)	00198000	70.29
	ADDED		300 CONTINUE	00198100	70.29
	ADDED		IF(J.LE.NBRPTS) GO TO 400	00198200	70.29
	ADDED		IF(NPTS(IBC).GT.0) GO TO 350	00198300	70.29
	ADDED		FLINBP(IBRPT)=FLINBP(IBRPT)-DBLE(SGN*QBR(IBC))	00198400	70.29
	ADDED		GO TO 600	00198500	70.29
	ADDED		350 CONTINUE	00198600	70.29
	ADDED	C	THIS BRANCH HAS A FIXED PRESSURE AT ONE END.	00198700	70.29
	ADDED	C	CALCULATE THE FORCING TERM (INFLOW) DUE TO	00198800	70.29
	ADDED	C	THE FIXED PRESSURE.	00198900	70.29
	ADDED	C		00199000	70.29
	ADDED		FLINBP(IBRPT)=FLINBP(IBRPT)	00199100	70.29
	ADDED		1 + DBLE(BRCON(IBC)*(PBRPT(J) -SGN*(POTHE(IBC)+DPUMP(IBC))))	00199200	70.29
	ADDED		GO TO 500	00199300	70.29
	ADDED		400 CONTINUE	00199400	70.29
	ADDED		IF(NPTS(IBC).GT.0) GO TO 450	00199500	70.29
	ADDED		IF(DPUMP(IBC).NE.0.0) GO TO 450	00199600	70.29
	ADDED		FLINBP(IBRPT)=FLINBP(IBRPT)-DBLE(SGN*QBR(IBC))	00199700	70.29
	ADDED		GO TO 600	00199800	70.29

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OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	450 CONTINUE		00199900 70.29
	ADDED	BMATRIX( IBRPT, J) = -DBLE( BRCON( IBC) ) + BMATRIX( IBRPT, J)		00200000 70.29
	ADDED	FLINBP( IBRPT) = FLINBP( IBRPT)		00200100 70.29
	ADDED	1 -DBLE( SGN*BRCON( IBC) *( POTHE( IBC) + DPUMP( IBC) ) )		00200200 70.29
	ADDED	500 CONTINUE		00200300 70.29
	ADDED	BMATRIX( IBRPT, IBRPT) = BMATRIX( IBRPT, IBRPT) + DBLE( BRCON( IBC) )		00200400 70.29
	ADDED	600 CONTINUE		00200500 70.29
	ADDED	650 CONTINUE		00200600 70.29
EBUG06	ADDED	C CALL MPRINT( NBRPTS, NBRPTS, 100, 100, BMATRIX)		00200700 70.29
EBUG07	ADDED	C WRITE( 6, 8007) ( IF, FLINBP( IF), IF=1, NBRPTS)		00200800 70.29
	ADDED	C8007 FORMAT( 1X, 'DEBUG07 IBRPT FLINBP', ( 10X, 14, 3X, G13.6) )		00200900 70.29
	ADDED	C		00201000 70.29
	ADDED	C SOLVE THE SIMULTANEOUS NODE EQUATIONS		00201100 70.29
	ADDED	C FOR THE PRESSURES AT THE BRANCH POINTS		00201200 70.29
	ADDED	C		00201300 70.29
	ADDED	C CALL SOLF4( BMATRIX, FLINBP, PDUBL, NBRPTS, 70, NOGOOD)		00201400 70.29
	ADDED	C IF( NOGOOD.NE.1) RETURN		00201500 70.29
	ADDED	C		00201600 70.29
EBUG07A	ADDED	C WRITE( 6, 8107) ( IP, PBRPT( IP), IP=1, NBRPTS)		00201700 70.29
	ADDED	C8107 FORMAT( 1X, 'DEBUG07A BRANCH PT. PRESSURE', ( 12X, 14, 8X, G13.6) )		00201800 70.29
	ADDED	C DO 700 IBRPT=1, NBRPTS		00201900 70.29
	ADDED	C PBRPT( IBRPT) = SNGL( PDUBL( IBRPT) )		00202000 70.29
	ADDED	700 CONTINUE		00202100 70.29
	ADDED	750 CONTINUE		00202200 70.29
	ADDED	C		00202300 70.29
	ADDED	C UPDATE THE FLOW RATES IN ALL BRANCHES		00202400 70.29
	ADDED	C USING THE PRESSURES COMPUTED ABOVE		00202500 70.29
	ADDED	C		00202600 70.29
	ADDED	C		00202700 70.29
	ADDED	C NFIN=0		00202800 70.29
	ADDED	C DO 950 IBRPT=1, NBRPTS		00202900 70.29
	ADDED	C NST=NFIN+1		00203000 70.29
	ADDED	C NFIN=NFIN+IABS( NBCON( IBRPT) )		00203100 70.29
	ADDED	C DO 950 N=NST, NFIN		00203200 70.29
	ADDED	C J=JBRPT( N)		00203300 70.29
	ADDED	C IF( IBCON( N).GT.0) GO TO 800		00203400 70.29
	ADDED	C IF( J.LE.NBRPTS) GO TO 950		00203500 70.29
	ADDED	C JBC=IBCON( N)		00203600 70.29
	ADDED	C IBC=IABS( JBC)		00203700 70.29
	ADDED	C SGN=JBC/IBC		00203800 70.29
	ADDED	C GO TO 850		

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
	ADDED	800 CONTINUE		00203900 70.29
	ADDED	IBC=IBCON(N)		00204000 70.29
	ADDED	SGN=1.0		00204100 70.29
	ADDED	850 CONTINUE		00204200 70.29
	ADDED	IF(NPTS(IBC).LE.0) GO TO 950		00204300 70.29
	ADDED	870 CONTINUE		00204400 70.29
	ADDED	DP=SNGL(PDOUBL(IBRPT))-PDOUBL(J))+SGN*(POTHE(IBC)+DPUMP(IBC))		00204500 70.29
	ADDED	900 CONTINUE		00204600 70.29
	ADDED	QOLD=QBR(IBC)		00204700 70.29
	ADDED	QBR(IBC)=SGN*BRCON(IBC)*DP		00204800 70.29
	ADDED	IF(DPUMP(IBC).GT.0.0) QBR(IBC)=(QOLD+QBR(IBC))/2.0		00204900 70.29
EBUG08	ADDED	C WRITE(6,8008) IBC, QBR(IBC), IBRPT, J, DP		00205000 70.29
	ADDED	C8008 FORMAT(1X,'DEBUG08 IBC=',14,' QBR(IBC)=',G13.6,' IBRPT=',14,		00205100 70.29
	ADDED	C 1 ' J=',14,' DP=',G13.6)		00205200 70.29
	ADDED	920 CONTINUE		00205300 70.29
	ADDED	ABSERR=ABS(QOLD-QBR(IBC))		00205400 70.29
	ADDED	DIV=AMINI(ABS(QOLD),ABS(QBR(IBC)))		00205500 70.29
	ADDED	IF(ABSERR.LE.TOLABS.OR.DIV.LE.TOLABS) GO TO 950		00205600 70.29
	ADDED	RELERR=ABSERR/DIV		00205700 70.29
	ADDED	IF(RELERR.LE.RELMAX) GO TO 950		00205800 70.29
	ADDED	MAXERR=IBC		00205900 70.29
	ADDED	RELMAX=RELERR		00206000 70.29
	ADDED	950 CONTINUE		00206100 70.29
	ADDED	ITER8=ITER8+1		00206200 70.29
	ADDED	IF(RELMAX.LE.TOLERR) RETURN		00206300 70.29
	ADDED	980 CONTINUE		00206400 70.29
	ADDED	IF(ITER8.LT.LIMIT) GO TO 100		00206500 70.29
	ADDED	NFIN=0		00206600 70.29
	ADDED	DO 1000 IB=1,MAXERR		00206700 70.29
	ADDED	NST=NFIN+1		00206800 70.29
	ADDED	NFIN=NFIN+IABS(NPTS(IB))		00206900 70.29
	ADDED	1000 CONTINUE		00207000 70.29
	ADDED	WRITE(6,9000) RELMAX, LIMIT, (IBRAN(I),I=NST,NFIN)		00207100 70.29
	ADDED	9000 FORMAT(1H1////1X,49(1H*),' WARNING ',49(1H*))/4X,	'THE FLOW ',	00207200 70.29
	ADDED	1 'RATE IN THE BRANCH DESCRIBED BELOW HAS A RELATIVE ERROR OF ',		00207300 70.29
	ADDED	2 1PE12.5,' AFTER ',13,' ITERATIONS'//1X,107(1H*)/(1H0,4X,2514)		00207400 70.29
	ADDED	RETURN		00207500 70.29
	ADDED	END		00207600 70.29
	ADDED	SUBROUTINE SOLF4(B,Y,X,N,NMAX,NOGOOD)		00207700 70.29
	ADDED	REAL*8 B, Y, X, C		00207800 70.29

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OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	DIMENSION B(NMAX,NMAX), Y(NMAX), X(NMAX)	00207900	70.29
	ADDED	C THIS PROGRAM SOLVES A SET OF SIMULTANEOUS LINEAR ALGEBRAIC	00208000	70.29
	ADDED	C EQUATIONS BY OPTIMIZED NORMALIZED ELIMINATION	00208100	70.29
	ADDED	C THE COEFFICIENTS AND RIGHT HAND SIDES ARE LOST	00208200	70.29
	ADDED	M=N	00208300	70.29
	ADDED	10 MM=M-1	00208400	70.29
	ADDED	C NORMALIZE COEFFICIENTS	00208500	70.29
	ADDED	DO 20 I=1,M	00208600	70.29
	ADDED	C=0.0D0	00208700	70.29
	ADDED	DO 12 J=1,M	00208800	70.29
	ADDED	12 C=DMAX1(C,DABS(B(I,J)))	00208900	70.29
	ADDED	IF (C) 200,200,13	00209000	70.29
	ADDED	13 IF (C-1.0D0) 14,20,14	00209100	70.29
	ADDED	14 DO 16 J=1,M	00209200	70.29
	ADDED	16 B(I,J)=B(I,J)/C	00209300	70.29
	ADDED	Y(I)=Y(I)/C	00209400	70.29
	ADDED	20 CONTINUE	00209500	70.29
	ADDED	C OPTIMIZE ROW SELECTION	00209600	70.29
	ADDED	IM=0	00209700	70.29
	ADDED	C=0.0D0	00209800	70.29
	ADDED	DO 25 I=1,M	00209900	70.29
	ADDED	IF (DABS(B(I,M))-C) 25,25,22	00210000	70.29
	ADDED	22 IM=I	00210100	70.29
	ADDED	C=DABS(B(I,M))	00210200	70.29
	ADDED	25 CONTINUE	00210300	70.29
	ADDED	IF (C) 200,200,27	00210400	70.29
	ADDED	27 IF (MM) 100,100,28	00210500	70.29
	ADDED	28 DO 29 J=1,M	00210600	70.29
	ADDED	C=B(IM,J)	00210700	70.29
	ADDED	B(IM,J)=B(M,J)	00210800	70.29
	ADDED	29 B(M,J)=C	00210900	70.29
	ADDED	C=Y(IM)	00211000	70.29
	ADDED	Y(IM)=Y(M)	00211100	70.29
	ADDED	Y(M)=C	00211200	70.29
	ADDED	C REDUCE ORDER OF SET	00211300	70.29
	ADDED	DO 40 I=1,MM	00211400	70.29
	ADDED	IF (B(I,M)) 32,40,32	00211500	70.29
	ADDED	32 Y(I)=B(M,M)*Y(I)-B(I,M)*Y(M)	00211600	70.29
	ADDED	DO 35 J=1,MM	00211700	70.29
	ADDED	35 B(I,J)=B(M,M)*B(I,J)-B(I,M)*B(M,J)	00211800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	40 CONTINUE			00211900 70.29
ADDED	M=MM			00212000 70.29
ADDED	GO TO 10			00212100 70.29
ADDED	C READY TO CALCULATE X VALUES			00212200 70.29
ADDED	100 X(I)=Y(I)/B(I,1)			00212300 70.29
ADDED	DO 120 I=2,N			00212400 70.29
ADDED	C=Y(I)			00212500 70.29
ADDED	IM=I-1			00212600 70.29
ADDED	DO 110 J=1,IM			00212700 70.29
ADDED	110 C=C-B(I,J)*X(J)			00212800 70.29
ADDED	120 X(I)=C/B(I,1)			00212900 70.29
ADDED	122 NOGOOD=1			00213000 70.29
ADDED	RETURN			00213100 70.29
ADDED	200 WRITE(6,901)			00213200 70.29
ADDED	NOGOOD=2			00213300 70.29
ADDED	RETURN			00213400 70.29
ADDED	901 FORMAT (3H0EQUATION SET SINGULAR IN SOLVE)			00213500 70.29
ADDED	END			00213600 70.29
ADDED	SUBROUTINE OUTPUT			00213700 70.29
ADDED	COMMON /MUFCON/			00213800 70.29
ADDED	1 A(3), COERR, CONSIS(3,600), GC,			00213900 70.29
ADDED	2 IBCON(600), IFLUID, IOPT(10),			00214000 70.29
ADDED	3 ITEMP, JBRPT(600), LABEL(20,3),			00214100 70.29
ADDED	4 LEVEL, MBRAN(850), NBRAN,			00214200 70.29
ADDED	5 NBRPTS, NPIS(150), PBRPT(250),			00214300 70.29
ADDED	6 QBR(150), QERR, RHO(600), TBULK(500),			00214400 70.29
ADDED	7 TOLERR, VISC(600), XDOTA(500)			00214500 70.29
ADDED	COMMON /MUFCON/ INOUT(100), NDUMBP, LOOP			00214600 70.29
ADDED	COMMON /PUNT/ MMEM, MNODES, DATE			00214700 70.29
ADDED	COMMON /PUNT/ TIME			00214800 70.29
ADDED	DIMENSION IFIND(150), NODE(500), NSKIP(150),			00214900 70.29
ADDED	1 PCON(500), PRESS(500)			00215000 70.29
ADDED	DIMENSION ICONST(3,600)			00215100 70.29
ADDED	DIMENSION RTAB(5), R2KTAB(5)			00215200 70.29
ADDED	EQUIVALENCE (ICONST(1,1), CONST(1,1))			00215300 70.29
ADDED	REAL*8 DATE			00215400 70.29
ADDED	DATA RTAB/ 0.4, 0.5, 0.6, 0.7, 0.8 /			00215500 70.29
ADDED	DATA BLANK/4H /, X/4HX /, OPAREN/4H ( /, CPAREN/4H) /			00215600 70.29
ADDED	IFIND(1)=1			00215700 70.29
ADDED	NBR=NBRAN+1			00215800 70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	DO 20 IB=2,NBR		00215900 70.29
	ADDED	IFIND(IB)=IFIND(IB-1)+IABS(NPTS(IB-1))		00216000 70.29
	ADDED	20 CONTINUE		00216100 70.29
	ADDED	NPAGES=0		00216200 70.29
	ADDED	KOUNTR=0		00216300 70.29
	ADDED	NDO=NBPTS+NDUMBP		00216400 70.29
	ADDED	LINE=28		00216500 70.29
	ADDED	NB2=0		00216600 70.29
	ADDED	DO 80 IBP=1,NDO		00216700 70.29
	ADDED	NB1=NB2+1		00216800 70.29
	ADDED	NB2=NB2+IABS(NBCON(IBP))		00216900 70.29
	ADDED	DO 80 NB=NB1,NB2		00217000 70.29
	ADDED	IF(IBCON(NB).LE.0) GO TO 80		00217100 70.29
	ADDED	IB=IBCON(NB)		00217200 70.29
	ADDED	LINE=LINE+3		00217300 70.29
	ADDED	NP=IABS(NPTS(IB))-1		00217400 70.29
	ADDED	IF(LINE+NP.LE.23) GO TO 70		00217500 70.29
	ADDED	IF(NP.LT.6) GO TO 60		00217600 70.29
	ADDED	IF(LINE.GT.20) GO TO 40		00217700 70.29
	ADDED	NP=NP-3		00217800 70.29
	ADDED	KOUNTR=KOUNTR+3		00217900 70.29
	ADDED	LINE=0		00218000 70.29
	ADDED	GO TO 45		00218100 70.29
	ADDED	40 CONTINUE		00218200 70.29
	ADDED	LINE=3		00218300 70.29
	ADDED	45 CONTINUE		00218400 70.29
	ADDED	NPAGES=NPAGES+1		00218500 70.29
	ADDED	NSKIP(NPAGES)=KOUNTR		00218600 70.29
	ADDED	IF(NP+LINE.LE.23) GO TO 50		00218700 70.29
	ADDED	NPSAV=NP		00218800 70.29
	ADDED	NP=NP-28+LINE		00218900 70.29
	ADDED	IF(NP.LT.3) NP=3		00219000 70.29
	ADDED	KOUNTR=KOUNTR+NPSAV-NP		00219100 70.29
	ADDED	LINE=0		00219200 70.29
	ADDED	GO TO 45		00219300 70.29
	ADDED	50 CONTINUE		00219400 70.29
	ADDED	KOUNTR=KOUNTR+NP		00219500 70.29
	ADDED	LINE=NP+5		00219600 70.29
	ADDED	GO TO 80		00219700 70.29
	ADDED	60 CONTINUE		00219800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ MESSAGE

FILENAME=MUFAN

DECKNAME=MUFAN

YY.DDI

ADDED	NPAGES=NPAGES+1	00219900	70.29
ADDED	NSKIP(NPAGES)=KOUNTR	00220000	70.29
ADDED	LINE=NP+9	00220100	70.29
ADDED	GO TO 75	00220200	70.29
ADDED	70 CONTINUE	00220300	70.29
ADDED	LINE=LINE+NP+5	00220400	70.29
ADDED	75 CONTINUE	00220500	70.29
ADDED	KOUNTR=KOUNTR+NP	00220600	70.29
ADDED	80 CONTINUE	00220700	70.29
ADDED	NSKIP(NPAGES+1)=0	00220800	70.29
ADDED	INODE=0	00220900	70.29
ADDED	NB2=0	00221000	70.29
ADDED	NFIN=0	00221100	70.29
ADDED	INIT=2	00221200	70.29
ADDED	LINE=0	00221300	70.29
ADDED	IPAGE=1	00221400	70.29
ADDED	DO 300 IBP=1,NDU	00221500	70.29
ADDED	NB1=NB2+1	00221600	70.29
ADDED	NB2=NB2+IABS(NBCON(IBP))	00221700	70.29
ADDED	IFOUND=1	00221800	70.29
ADDED	DO 300 NB=NB1,NB2	00221900	70.29
ADDED	IF(IBC(NB).LE.0) GO TO 300	00222000	70.29
ADDED	IB=IBC(NB)	00222100	70.29
ADDED	JBP=JBRPT(NB)	00222200	70.29
ADDED	GO TO (90,95), IFOUND	00222300	70.29
ADDED	90 CONTINUE	00222400	70.29
ADDED	IFOUND=2	00222500	70.29
ADDED	INODE=INODE+1	00222600	70.29
ADDED	PRESS(INODE)=PBRPT(IBP)	00222700	70.29
ADDED	INDEX=IFIND(IB)	00222800	70.29
ADDED	NODE(INODE)=IBRAN(INDEX)	00222900	70.29
ADDED	PCON(INODE)=BLANK	00223000	70.29
ADDED	IF(IBP.GT.NBRPTS) PCON(INODE)=X	00223100	70.29
ADDED	95 CONTINUE	00223200	70.29
ADDED	CUMFPD=0.0	00223300	70.29
ADDED	CUMEPD=0.0	00223400	70.29
ADDED	CUMPD=0.0	00223500	70.29
ADDED	100 CONTINUE	00223600	70.29
ADDED	QB=ABS(QBR(IB))	00223700	70.29
ADDED	NUNDP=0	00223800	70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

LD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
	ADDED	DPUNK=BLANK		00223900 70.29
	ADDED	ORFD=0.0		00224000 70.29
	ADDED	NST=IFIND(IB)		00224100 70.29
	ADDED	NFIN=IFIND(IB+1)-1		00224200 70.29
	ADDED	FLOCON=BLANK		00224300 70.29
	ADDED	IF(NPTS(IB).LT.0) FLOCON=X		00224400 70.29
	ADDED	IF(QBR(IB).GE.0.0) GO TO 150		00224500 70.29
	ADDED	PBP1=PBRPT(JBP)		00224600 70.29
	ADDED	PBP2=PBRPT(IBP)		00224700 70.29
	ADDED	MEMF=0		00224800 70.29
	ADDED	IFROM=1		00224900 70.29
	ADDED	ITO=0		00225000 70.29
	ADDED	N=NFIN-1		00225100 70.29
	ADDED	NSTOP=NST		00225200 70.29
	ADDED	INC=-1		00225300 70.29
	ADDED	GO TO 160		00225400 70.29
	ADDED	150 CONTINUE		00225500 70.29
	ADDED	PBP1=PBRPT(IBP)		00225600 70.29
	ADDED	PBP2=PBRPT(JBP)		00225700 70.29
	ADDED	IFROM=0		00225800 70.29
	ADDED	ITO=1		00225900 70.29
	ADDED	N=NST		00226000 70.29
	ADDED	NSTOP=NFIN-1		00226100 70.29
	ADDED	INC=1		00226200 70.29
	ADDED	160 CONTINUE		00226300 70.29
	ADDED	IF(NSKIP(IPAGE).NE.LINE) GO TO 165		00226400 70.29
	ADDED	WRITE(6,6000) DATE,ITIME,IPAGE,NPAGES,((LABEL(I,J),I=1,19),J=1,3)		00226500 70.29
	ADDED	6000 FORMAT(1H1//1H0,32(1H*), ' MUFAN FLOW AND PRESSURE DROP PRINTOUT',		00226600 70.29
	ADDED	1 ' * ',A8,2X,14,' ** PAGE',13,' OF',13,' *',//17X,19A4/17X,		00226700 70.29
	ADDED	2 19A4/17X,19A4//1H0,57X,11(1H-),'CUMULATIVE',13(1H-)/		00226800 70.29
	ADDED	3 28X,'ELEVATION',4X,'FRICTION',22X,'ELEVATION',4X,		00226900 70.29
	ADDED	4 'FRICTION' /10X,3(5X,8HPRESSURE),4X,3(5X,8HPRESSURE)/4X,		00227000 70.29
	ADDED	5 'MEMBER ',3(4X,9HDROP, PSI),4X,3(4X,9HDROP, PSI),4X,		00227100 70.29
	ADDED	6 'REYNOLDS NO' /1X,107(1H-)/2X)		00227200 70.29
	ADDED	IPAGE=IPAGE+1		00227300 70.29
	ADDED	165 CONTINUE		00227400 70.29
	ADDED	WRITE(6,6001) QB, FLOCON		00227500 70.29
	ADDED	6001 FORMAT( 1H0,32(1H.), ' BEGINNING OF BRANCH - FLOW=',G12.5,A2,		00227600 70.29
	ADDED	1 34(1H.)/1X,1H.,106X,1H. )		00227700 70.29
	ADDED	GO TO 172		00227800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY,DD
ADDED	170 CONTINUE			00227900 70.29
ADDED	IF(INSKIP(IPAGE).NE.LINE) GO TO 172			00228000 70.29
ADDED	WRITE(6,6000) DATE,ITIME,IPAGE,NPAGES,LABEL			00228100 70.29
ADDED	IPAGE=IPAGE+1			00228200 70.29
ADDED	172 CONTINUE			00228300 70.29
ADDED	INDEX1=N+IFROM			00228400 70.29
ADDED	INDEX2=N+ITO			00228500 70.29
ADDED	MEM=MBRAN(N)			00228600 70.29
ADDED	IF(ITYPE(MEM)-100000000) 180,176,178			00228700 70.29
ADDED	176 CONTINUE			00228800 70.29
ADDED	DPCON=X			00228900 70.29
ADDED	REYN0=-1.0E20			00229000 70.29
ADDED	GO TO 187			00229100 70.29
ADDED	178 CONTINUE			00229200 70.29
ADDED	IF(ITYPE(MEM).NE.300000000) GO TO 179			00229300 70.29
ADDED	REYN0=-1.0E20			00229400 70.29
ADDED	FPDR0P=-CONSTS(2,MEM)			00229500 70.29
ADDED	DPCON=X			00229600 70.29
ADDED	GO TO 190			00229700 70.29
ADDED	179 CONTINUE			00229800 70.29
ADDED	IF(NUNDP.NE.0) GO TO 190			00229900 70.29
ADDED	NUNDP=N			00230000 70.29
ADDED	SAVCPD=CUMPD			00230100 70.29
ADDED	FPDR0P=0.0			00230200 70.29
ADDED	GO TO 190			00230300 70.29
ADDED	180 CONTINUE			00230400 70.29
ADDED	DPCON=BLANK			00230500 70.29
ADDED	IT=MOD(ITYPE(MEM),10000000)			00230600 70.29
ADDED	IF(IT.LI.1000000) GO TO 182			00230700 70.29
ADDED	IT=IT/1000000+41			00230800 70.29
ADDED	FPDR0P=-PTABLE(IT,QB)			00230900 70.29
ADDED	REYN0=-1.0E20			00231000 70.29
ADDED	GO TO 190			00231100 70.29
ADDED	182 CONTINUE			00231200 70.29
ADDED	IF(IT.LI.10000) GO TO 185			00231300 70.29
ADDED	REYN0=-1.0E20			00231400 70.29
ADDED	GO TO 187			00231500 70.29
ADDED	185 CONTINUE			00231600 70.29
ADDED	REYN0=4.2441317E-3*QB/(VISC(MEM)*CONSTS(1,MEM))			00231700 70.29
ADDED	187 CONTINUE			00231800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	FPDROP=RESIST(MEM,QB,INIT)*QB			00231900 70.29
ADDED	190 CONTINUE			00232000 70.29
ADDED	EPDROP=RHO(MEM)*(XDOTA(INDEX1))-XDOTA(INDEX2))			00232100 70.29
ADDED	PDROP=FPDROP+EPDROP			00232200 70.29
ADDED	CUMPD=CUMPD+PDROP			00232300 70.29
ADDED	IF(NUNDP.GT.0) GO TO 210			00232400 70.29
ADDED	LINE=LINE+1			00232500 70.29
ADDED	CUMFPD=CUMFPD+FPDROP			00232600 70.29
ADDED	CUMEPD=CUMEPD+EPDROP			00232700 70.29
ADDED	INODE=INODE+1			00232800 70.29
ADDED	NODE(INODE)=IBRAN(INDEX2)			00232900 70.29
ADDED	PRESS(INODE)=PBPI-CUMPD			00233000 70.29
ADDED	PCON(INODE)=BLANK			00233100 70.29
ADDED	200 CONTINUE			00233200 70.29
ADDED	WRITE(6,6002) IBRAN(INDEX1), IBRAN(INDEX2), PDROP, EPDROP,			00233300 70.29
ADDED	1 DPUNK, FPDROP, DPCON, CUMPD, CUMEPD, REYNO			00233400 70.29
ADDED	6002 FORMAT(1X,2H.,13,2H -,13,2G14.4,A2,G11.4,A4,3G13.4,2X,G10.5,2H.)			00233500 70.29
ADDED	DPUNK=BLANK			00233600 70.29
ADDED	210 CONTINUE			00233700 70.29
ADDED	IF(N.EQ.NSTOP) GO TO 220			00233800 70.29
ADDED	N=N+INC			00233900 70.29
ADDED	GO TO 170			00234000 70.29
ADDED	220 CONTINUE			00234100 70.29
ADDED	IF(NUNDP) 236,240,221			00234200 70.29
ADDED	221 CONTINUE			00234300 70.29
ADDED	N=NUNDP			00234400 70.29
ADDED	NUNDP=-1			00234500 70.29
ADDED	DPUNK=UPAREN			00234600 70.29
ADDED	DPCON=CPAREN			00234700 70.29
ADDED	FPDROP=PBPI-PBP2-CUMPD			00234800 70.29
ADDED	CUMPD=SAVCPD			00234900 70.29
ADDED	REYNO=-1.0E20			00235000 70.29
ADDED	IF(FPDROP.LE.0.0) GO TO 170			00235100 70.29
ADDED	IF(CONSTS(1,MEM).LE.0.0) GO TO 170			00235200 70.29
ADDED	C CALCULATE REQUIRED ORFICE DIAMETER			00235300 70.29
ADDED	MEM=MBRAN(N)			00235400 70.29
ADDED	REYNO=4.2441317E-3*QB/(VISC(MEM)*CONSTS(1,MEM))			00235500 70.29
ADDED	R2K=QB/(900.0*3.14159*CONSTS(1,MEM)**2*SQRT(64.4*FPDROP))			00235600 70.29
ADDED	DO 224 L=1,5			00235700 70.29
ADDED	R2KTAB(L)=RTAB(L)**2*ORFICE(RTAB(L),REYNO)			00235800 70.29

OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

OLD SEQ	MESSAGE	FILENAME=MUFAN	DECKNAME=MUFAN	YY.DD
ADDED	224 CONTINUE			00235900 70.29
ADDED	IF(R2K-R2KTAB(1)) 234,226,228			00236000 70.29
ADDED	226 CONTINUE			00236100 70.29
ADDED	ORFD=RTAB(1)*CONSTS(1,MEM)			00236200 70.29
ADDED	GO TO 233			00236300 70.29
ADDED	228 CONTINUE			00236400 70.29
ADDED	IF(R2K-R2KTAB(5)) 232,230,234			00236500 70.29
ADDED	230 CONTINUE			00236600 70.29
ADDED	ORFD=RTAB(5)*CONSTS(1,MEM)			00236700 70.29
ADDED	GO TO 233			00236800 70.29
ADDED	232 CONTINUE			00236900 70.29
ADDED	CALL INT4(R2KTAB,RTAB,R2K,R)			00237000 70.29
ADDED	ORFD=R*CONSTS(1,MEM)			00237100 70.29
ADDED	233 CONTINUE			00237200 70.29
ADDED	CONSTS(2,MEM)=ORFD			00237300 70.29
ADDED	GO TO 170			00237400 70.29
ADDED	234 CONTINUE			00237500 70.29
ADDED	ORFD=-1.0			00237600 70.29
ADDED	GO TO 170			00237700 70.29
ADDED	236 CONTINUE			00237800 70.29
ADDED	IF(ORFD) 238,240,242			00237900 70.29
ADDED	238 CONTINUE			00238000 70.29
ADDED	WRITE(6,6006) QB, FLOCON			00238100 70.29
ADDED	6006 FORMAT(1X,1H.,106X,1H./1X,16(1H.),' END OF BRANCH - FLOW=',G12.5,			00238200 70.29
ADDED	1 A2,38H, REQ'D ORFICE DIAM OUT OF TABLE RANGE, 17(1H.)//2X)			00238300 70.29
ADDED	GO TO 244			00238400 70.29
ADDED	240 CONTINUE			00238500 70.29
ADDED	WRITE(6,6003) QB, FLOCON			00238600 70.29
ADDED	6003 FORMAT(1X,1H.,106X,1H./1X,35(1H.),' END OF BRANCH - FLOW=',G12.5,			00238700 70.29
ADDED	1 A2,36(1H.)//2X)			00238800 70.29
ADDED	GO TO 244			00238900 70.29
ADDED	242 CONTINUE			00239000 70.29
ADDED	WRITE(6,6007) QB, FLOCON, ORFD			00239100 70.29
ADDED	6007 FORMAT(1X,1H.,106X,1H./1X,19(1H.),' END OF BRANCH - FLOW=',G12.5,			00239200 70.29
ADDED	1 A2,20H, REQ'D ORFICE DIAM=',G11.3,20(1H.)//2X)			00239300 70.29
ADDED	244 CONTINUE			00239400 70.29
ADDED	IF(QBR(18).GE.0.0) GO TO 246			00239500 70.29
ADDED	IF(IABS(NBCON(JBP)).GE.2) GO TO 260			00239600 70.29
ADDED	PRESS(INODE)=PBRPT(JBP)			00239700 70.29
ADDED	NODE(INODE)=IBRAN(NFIN)			00239800 70.29



OLD VOL=SER=004783

DRC UPDATE

NEW VOL=SER=007208

FILE

TYPE

DECK

LANGUAGE

ADD YY.DDD HHMM

JOBNAME

CHG YY.DDD HHMM

JOBNAME

RECD

MUFAN

SOURCE

MUFAN

FORT

70.295 2211 D247USEF

70.295 2211 D247USEF

70.295 2211 D247USEF

70.295 2211 D247USEF

2

2



## APPENDIX B

### K-Factors



AEROJET-GENERAL CORPORATION  
AZUSA, CALIFORNIA

# QUADRILLE WORK SHEET

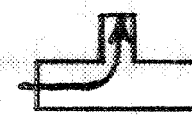
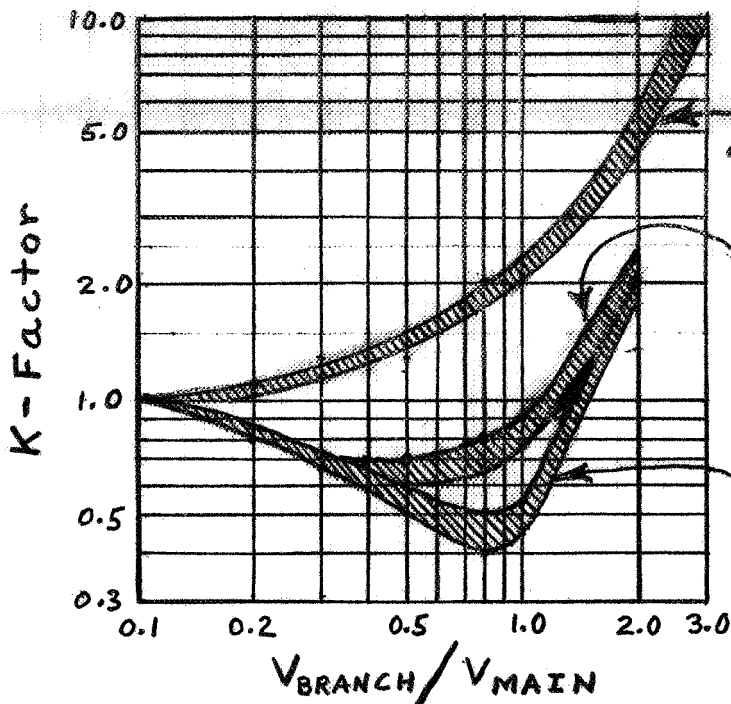
PAGE 1 OF 8 PAGES

DATE 9/23/70

SUBJECT K-Factors

BY D&M

WORK ORDER 1475-02-0183



90°

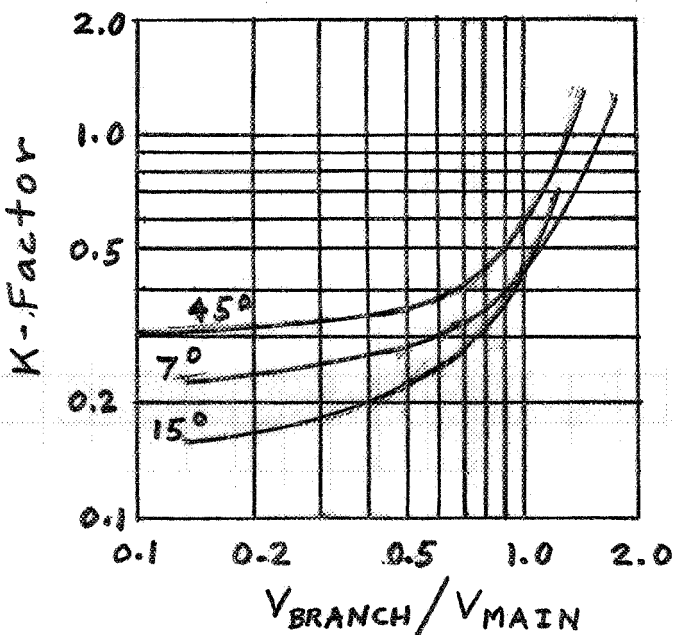


60°



45° or 30°

Read upper edge of curves for  
 $D_{\text{BRANCH}}/D_{\text{MAIN}} = 1/3$   
lower edge for  
 $D_{\text{BRANCH}}/D_{\text{MAIN}} = 1$



45° Branch  
90° Elbow



7° Branch  
90° Elbow



15° Branch  
25° Elbow



AEROJET-GENERAL CORPORATION  
AZUSA, CALIFORNIA

## QUADRILLE WORK SHEET

PAGE 2 OF 8 PAGES

DATE 9/23/70

SUBJECT K-Factors

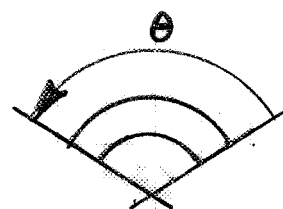
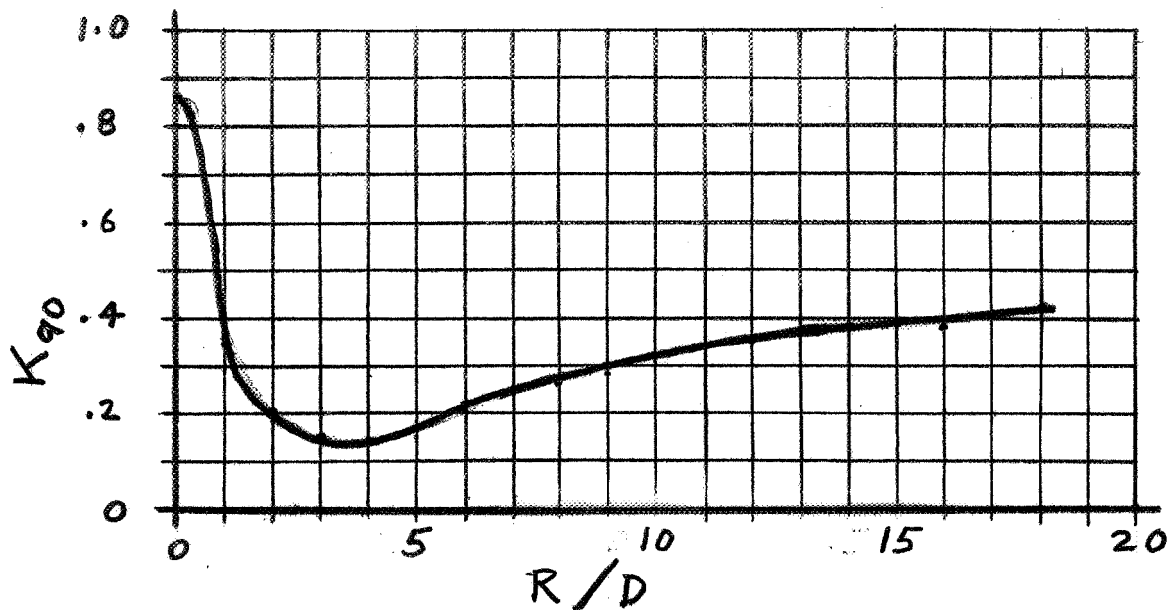
BY AGM

WORK ORDER 1475-02-0183

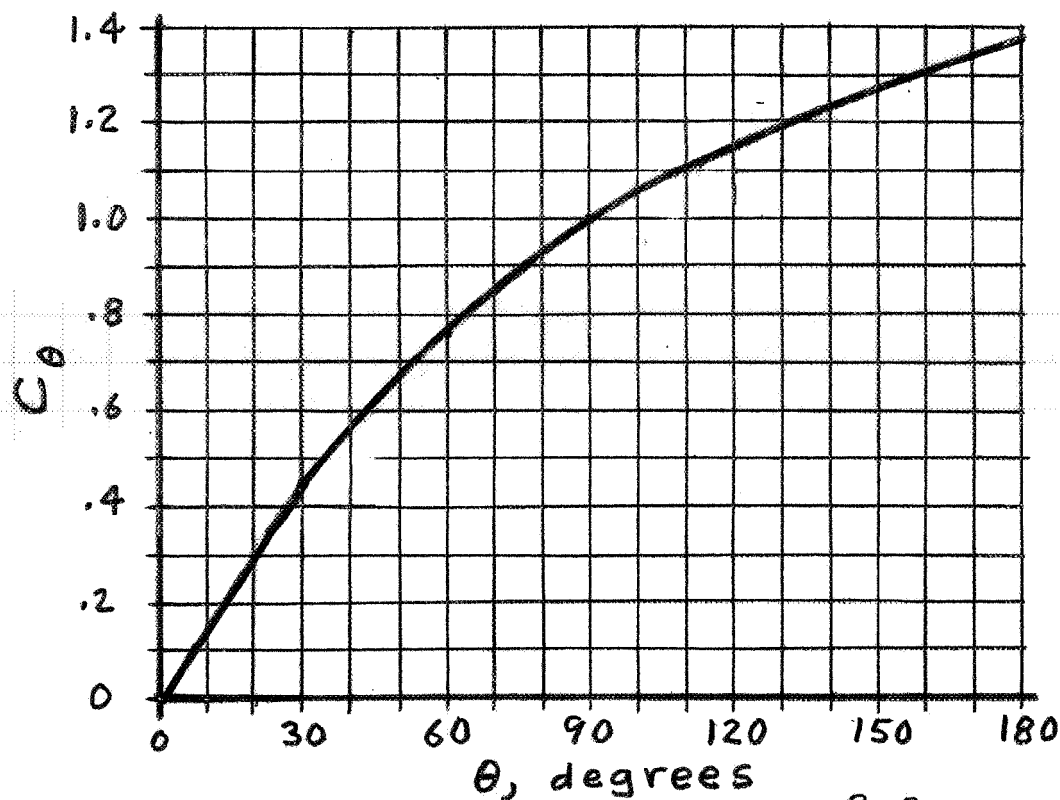
# K-Factor for 90° Tubing Bend



D is the  
inside  
diameter



$$K_{\theta} = C_{\theta} K_{90}$$





AEROJET-GENERAL CORPORATION  
AZUSA, CALIFORNIA

## QUADRILLE WORK SHEET

PAGE 3 OF 8 PAGES

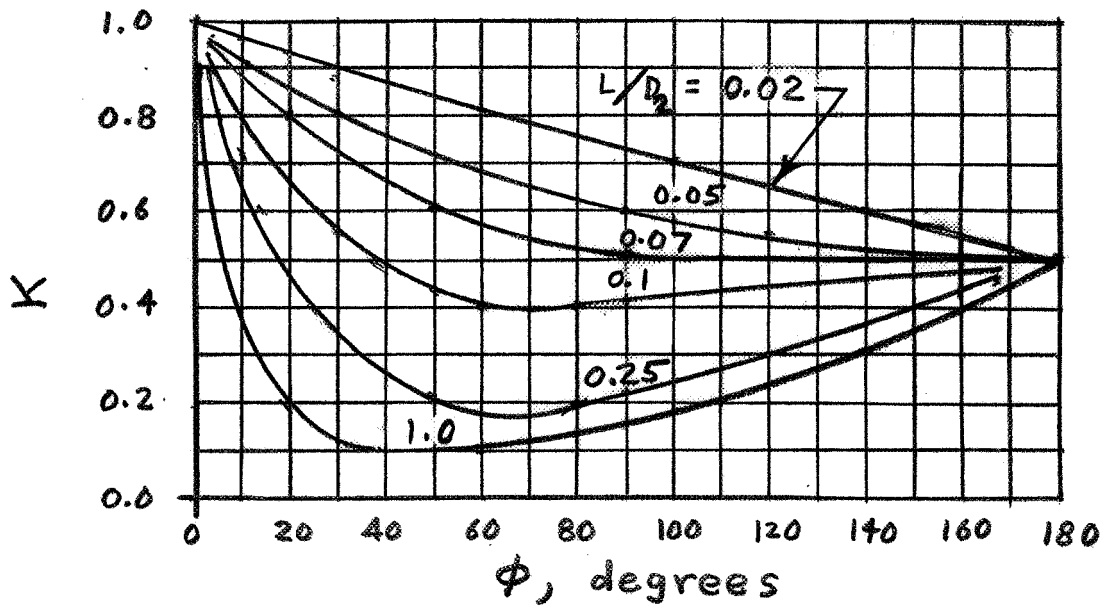
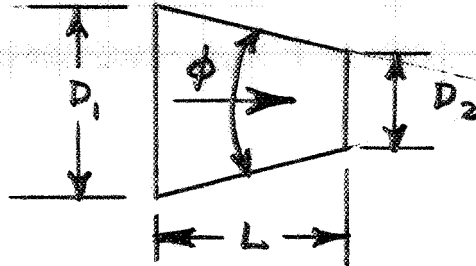
DATE 9/25/70

SUBJECT K-Factors

BY DM

WORK ORDER 1475-02-0183

### Gradual Contraction





AEROJET-GENERAL CORPORATION  
AZUSA, CALIFORNIA

## QUADRILLE WORK SHEET

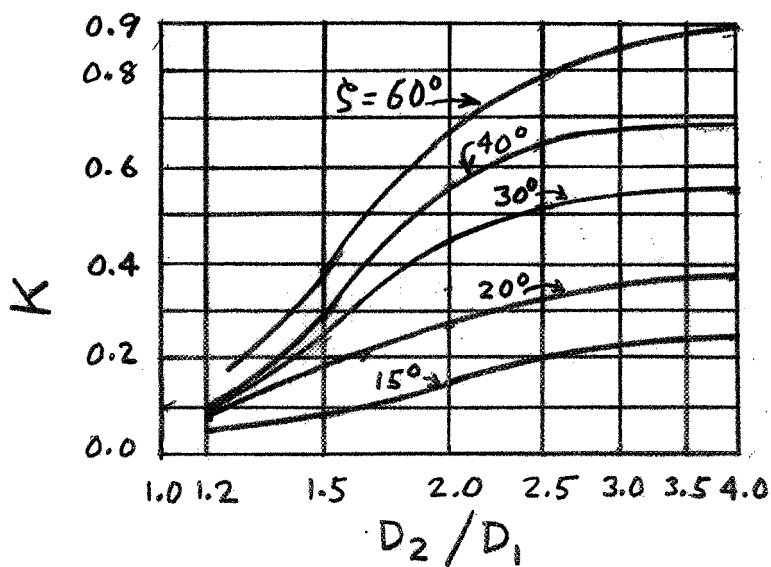
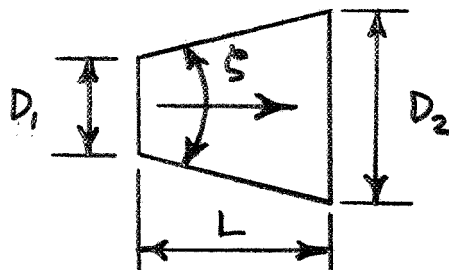
PAGE 4 OF 8 PAGES

DATE 9/28/70

SUBJECT K-Factors BY QJM

WORK ORDER 1475-02-0183

### Gradual Expansion





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QUADRILLE WORK SHEET

PAGE 5 OF 8 PAGES

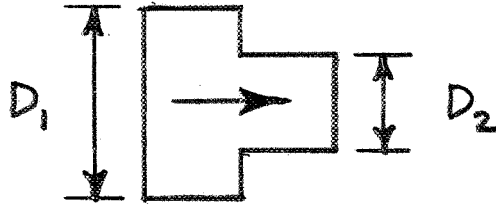
DATE 9/28/70

SUBJECT K-Factors

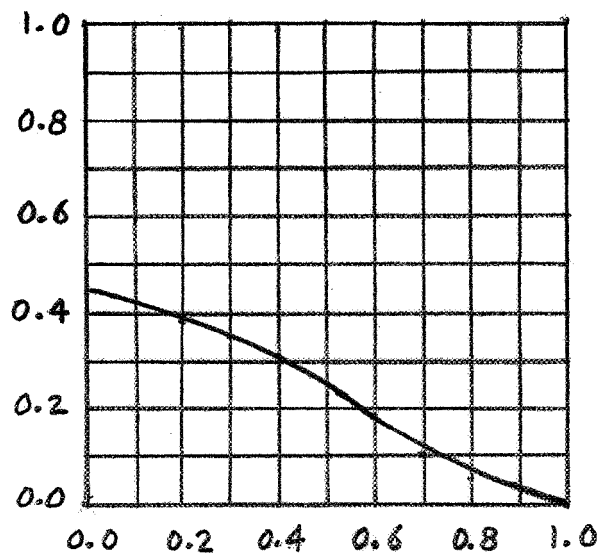
BY 22m

WORK ORDER 1475-02-0183

### Sudden Contraction



$$A_1 = \frac{\pi D_1^2}{4} \quad A_2 = \frac{\pi D_2^2}{4}$$





AEROJET-GENERAL CORPORATION  
AZUSA, CALIFORNIA

QUADRILLE WORK SHEET

PAGE 6 OF 8 PAGES

DATE 9/24/70

SUBJECT K-Factors

BY DGM

WORK ORDER 1475-02-0983

## Square Edged Orifice

The flow coefficient data from reference (4) has been modified to include pressure recovery. The pressure recovery factors used (from ref. 7) are shown below.

$D_o/D_i$	$\lambda$
0.20	0.95
0.30	0.90
0.40	0.83
0.50	0.75
0.60	0.645
0.65	0.59
0.70	0.535
0.75	0.465
0.80	0.400

For an orifice:

$$Q = 3600 \rho C A_o \sqrt{\frac{2g (P_1 - P_2)}{144 \rho}}$$

Where:  $Q$  = weight flow rate, lb/hr.  
 $C$  = flow coefficient  
 $A_o = \frac{\pi D_o^2}{576}$  = area of orifice, ft<sup>2</sup>.  
 $p$  = pressure, psi  
 $\rho$  = weight density, lb/ft<sup>3</sup>



AEROJET-GENERAL CORPORATION  
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## QUADRILLE WORK SHEET

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BY \_\_\_\_\_

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$$K = \left( \frac{D_i}{D_o} \right)^4 \frac{1}{C^2}$$

Where:

K = K-factor

D<sub>i</sub> = pipe inside diameterD<sub>o</sub> = orifice diameter



